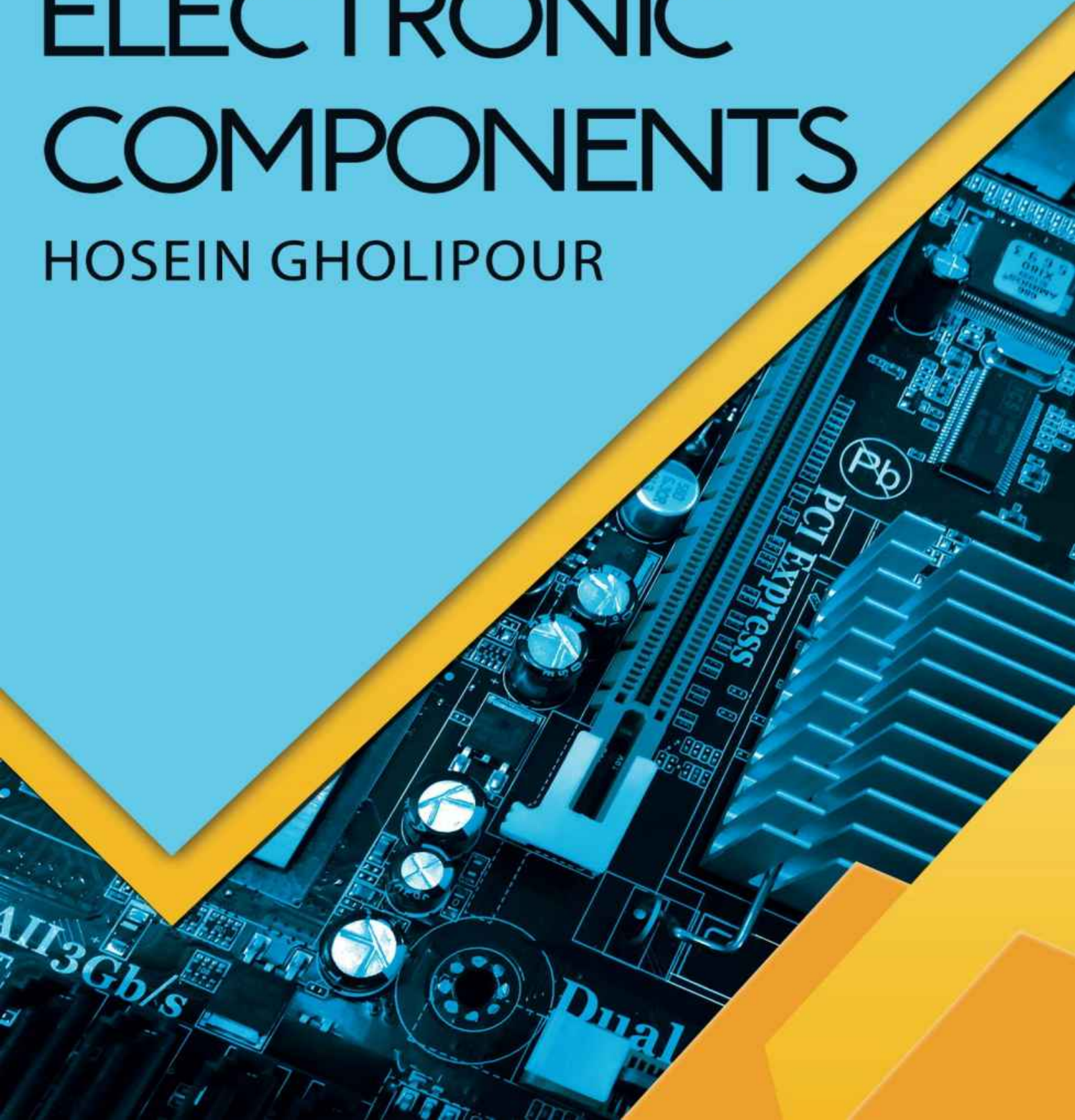


ENCYCLOPEDIA OF ELECTRONIC COMPONENTS

HOSEIN GHOLIPOUR



VISIT...

LANZAROTE
Caliente.COM

By : Hosein Gholipour

2/Encyclopedia of Electronic Components

Encyclopedia Of Electronic Components

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I would like to express my deepest gratitude to my wife who constantly encouraged me during the writing of this book with patience and endurance.

My sincere gratitude also goes to Mr. Mohammadi who showed tremendous support for the publish of this book.

Introduction

This book is the result of nearly 16 years of research on electronic components, warehouse management systems, and electronic component coding, covering the catalogs of the best manufacturers in the world,

hundreds of manufacturers' or retailers' websites, and a number of electronics standards.

Attempts were made to introduce every category of components in seven aspects, including the main characteristics for selection or purchase, pictures, the best or the most important manufacturers, and the components' markings.

The websites of all the manufacturers are listed at the end of the book.

This book was written to help all groups of people, such as industry experts, researchers, students, retailers, and purchasing agents.

Given my experience in different fields of activity in large industries including design, component separation in warehouses, design control, production control, production planning, national and international procurement supervision, and reverse engineering projects, the needs of the industries, universities, and the market are known to me ; therefore, I attempted to write a comprehensive book to meet these demands.

Considering the wide variety of electronic components, some groups of items may have been omitted, either due to their limited application and significance or because of lack of detailed information about them.

However, it is safe to say that the main categories are well-established and all electronic components may be attributed to one of the twenty-four main categories discussed. In addition, new components are introduced to the world of electronics every day. Accordingly, these newcomers will be covered in future editions.

Readers can contact me via e-mail at "hosein_gx@yahoo.com" to share more comprehensive information or corrections regarding the subjects discussed in this book.

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18. Modules, Hybrid, RF, and Microwave Components
19. Motors
20. PCB
21. Relay
22. Sensor
23. Switch
24. Test Equipment

1 Environmental Classification

1-1 Commercial-Grade Components

Commercial-grade components generally operate in a temperature range of 0 to 50 °C.

1-2 Industrial-Grade Components

Components with an operating temperature between -20 ~ +65 °C or -40 ~ +85 °C. In addition, these components are relatively resistant to vibration and impact to some extent.

1-3 Military-Grade Components

According to their application, these components are divided into four groups (in order of strictness of the standard):

Ground, marine, aviation, and Space . Their operating temperature is generally between -40 and +85 °C, and -55 and +125 °C. In addition, comprehensive standards have been established for them to be able to withstand harsh environments with intense temperature, vibration, impact, immersion in water, salt spray tests, in-flight and atmospheric pressure conditions (aerospace applications).

2 Classification Based on Assembly

Almost all Printed-Circuit-Board (PCB) mount Dual In-line Package (DIP) components have a Surface-Mount-Device (SMD) model too.

Therefore, any component is assembled on the board by one of the following methods: DIP PCB mount, SMD PCB mount, Cable mount, or Panel mount.

3 Tolerance

Letters representing tolerance in catalogs (part number) are generally one of the following:

The accuracy of the component with respect to the time or changes in the temperature or physical-environmental parameters, and is an abbreviation for Parts per Million. For example, if it is said that the frequency of a crystal is said to be 1 MHz, and its tolerance within the operating temperature range 20 ppm, it is meant that for every 1 million Hz (1 MHz), an error (displacement in the frequency) of 20 Hz takes place occurs.

There are different types of resistors, the most important of which are as follows:

1. Fixed Single Resistor
2. Fixed Array
3. Rheostat
4. Potentiometer
5. Light Dependent Resistor (LDR)
6. Thermistor
7. Voltage-Dependent Resistor (VDR) or Varistor

Function and Application: These components are used in all types of circuits for limiting current or voltage drop.

Main Specifications:

1 Kilo ohm = 1KR = 1000 R

1 Mega ohm = 1 MR = 1,000,000 R

The most important types are:

Carbon Film

Metal Film

Metal Oxide

Wirewound

Tables in the following pages compare the characteristics of some of these groups:

- Metal Oxide Resistors are available in typical and non-inductive models.
- The dimensions of SMD resistors often depend on the standards discussed at the end of this book.
- The resistance values are indicated according to E96, E48, E24, and E12 standards. E24 and E96 Series can be found on Page 17 below the picture illustrating resistor color bands.
- Overall, it is safe to say that Carbon resistors are actually typical resistors with a tolerance above 5%
- Metal Film resistors are accurate, featuring a low-tolerance (~ 1%).
- Metal Glaze resistors feature very high impedance (up to around 33 MR) values.
- Wirewound resistors feature high power (in the order of 3-100 W).
- Small Metal Oxide resistors feature low noise levels, high power, and favorable thermal coefficients.
-
- Thick-Film Power resistors feature high power and small dimensions (25,

50 W)

- SMD resistors are available in Thick-Film (e.g. Carbon Film), Thin-Film (e.g. Metal Film), and wirewound models.
- Metal Oxide Resistors are available in typical and non-inductive models.
- The dimensions of SMD resistors often depend on the standards discussed at the end of this book.
- The resistance values are indicated according to E96, E48, E24, and E12 standards. E24 and E96 Series can be found on Page 17 below the picture illustrating resistor color bands.
- Overall, it is safe to say that Carbon resistors are actually typical resistors with a tolerance above 5%.
- Metal Film resistors are accurate, featuring a low-tolerance ($\sim 1\%$).
- Metal Glaze resistors feature very high impedance (up to around 33 MR) values.

Type General
Characteristics
Type
SMD

Lower power and inductance, smaller dimensions

SMD

Wirewound

Higher power and able to withstand stronger pulses
porcelain

Construction The resistive paste is applied to a lasercut integrated ceramic piece.

The resistive wire is wound around a ceramic rod and then coated with porcelain silicone.

Advantages small-sized High pulsed power
glaze

The resistive
wire is wound around a ceramic rod and then

coated with
glaze.

High pulsed
power
Aluminum-clad

Coil embedded in an aluminum package.

High power

Disadvantages Limited power and voltage
Higher inductance compared to the film counterparts High price Higher
inductance compared to the film
counterparts

Range of Resistance 1~10M 0.1~33K 0.1~100K 0.1~120K

Power (W) Thermal
Coefficient (ppm/°C)

0.25 3~20 2.5~12 10~100
±200 ±100 ±200

- Metal Oxide Resistors are available in typical and non-inductive models.
- The dimensions of SMD resistors often depend on the standard cases discussed at the end of this book.
- The resistance values are indicated according to E96, E48, E24, and E12 standards. E24 and E96 Series can be found on Pages 15-16 in the picture illustrating resistor color bands.
- Overall, it is safe to say that Carbon resistors are actually typical resistors with a tolerance

above 5%.
±100

Type Film Hybrid General
Characteristics

Low tolerance and drift, favorable thermal coefficient Low inductance

Type Metal glass Metal oxide Metal Film

Carbon Film Carbon Hybrid

Construction

Advantages Film

Metal

glass on a ceramic body

Homogenized tin oxide film on a ceramic body in a helical notch Homogenized metal alloy film on a ceramic body in a notch

Helical

Homogenized carbon on a ceramic body in a notch

Helical

Carbon mold

Wide range of resistance, high voltage

Favorable thermal

coefficient, very low noise High accuracy, low thermal drift Low price

Disadvantages Limited resistance

High price High price

Medium

thermal drift Low

inductance, favorable

response to strong pulse and high voltage

High
tolerance and thermal drift, high noise,
small thermal coefficient.

Range of Resistance 100K~22M 0.2~100K 5~10M 1~10M 10~22M

Power (W) Thermal
Coefficient (ppm/°C)

- Metal Film resistors are accurate and feature low tolerance (~ 1%).
- Metal Glaze resistors feature very high impedance (up to around 33 MR) values.
- Wirewound resistors feature high power (in the order of 3-100 W).
- Small Metal Oxide resistors feature low noise levels, high power, and favorable thermal coefficients.
-
- Thick-Film Power resistors feature high power and small dimensions (25, 50 W)
- SMD resistors are available in Thick-Film (e.g. Carbon Film), Thin-Film (e.g. Metal Film), and wirewound models.
- Wirewound resistors (often DIP models) can be found in the following models: Vitreous enamel (manufactured by Welwyn)

Precision

0.25~1 0.5~7 0.25~3 0.25~2 0.25~1
±200 ±200 ±50 200~-1000

200~-2000 Power molded

Normal

Cement (Ceramic Case)

Fusible

Aluminum Clad

Thick-Film Power ==> (manufactured by Vishay)

Non inductive

Note: Sometimes, the ambient temperature affects the rated power of the component. For example, the nominal power of the fixed film resistor

indicated in datasheets is valid only below 70 °C. At 80 °C the power is reduced down to 80%, and at 100 °C down to 70%. For example, the power of a 1 W resistor becomes 0.8 W at 85 °C, and 0.7 W at 100 °C.

This is more evident in high-power cement resistors as their nominal power is only valid below

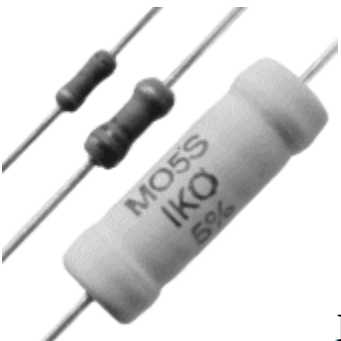
40-50 °C

Important Parameters Related Pictures



**SMD
Carbon film**

Resistance, tolerance, power, dimensions or case for



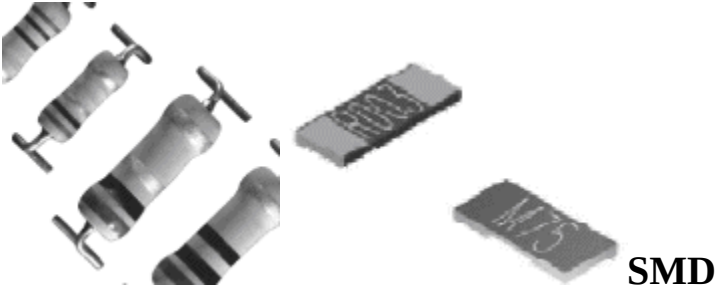
Metal oxide



Wirewound



Low ohm Res.



SMD



Aluminum Clad



High power RF Resistor Some manufacturers:

TY OHM, Ne OHM, Roederstein

High-Power RF Resistor Anaren, Bourns

Markings: Often color bands are used for carbon and metal resistors. The table in Page 17 lists the colors and their implications.

E3 50% tolerance (no longer used)

E6 20% tolerance (now seldom used)

E12 10% tolerance

E24 5% tolerance

E48 2% tolerance

E96 1% tolerance

E192 0.5, 0.25, 0.1% and higher tolerances

- The standards for E96 and E24 Series in the table are as follows:

The E24 standard is often used for resistors of 5% tolerance and comprises multiplications of the numbers above.

For example, for 20, we have: 2, 20, 200, 2K, 20K, 200K, 2M, 20M

The E96 standard, which is dedicated to 1% resistors, the multiplications

have similar implications. For example, for 121, we have: 1.21, 12.1, 121, 1.21K, 12.1K, 121K, 1.21M, 12.1M

- Wirewound resistors often have their resistance and tolerance printed on them, while a small number of manufacturers print the Mfr. Code.

- SMD resistors have merely their resistance printed on them according to the following standard. Typically, if the resistor has a tolerance of 5%, it has a three-digit number stamped on it. The first and second digits represent the number while the third digit is a factor of 10 or the number of zeros. If the resistor has a tolerance of 1%, it has a four-digit number stamped on it. The first, second, and third digits represent the number while the fourth digit is a factor of 10 or the number of zeros. For example:

222 = 2200 = 2.2K, 5%

4993 = 499000 = 499K, 1%

1R2 = 1.2R, 5%

100 215 464

100 101 215 218 464 470

102 221 475

100 102 104 215 221 223 464 475 481

105 226 487

105 106 226 229 487 493

107 232 499

100 105 107 109 220 226 232 234 470 487 499 505

110 237 511

110 111 237 240 511 517

113 243 523

110 113 114 237 243 246 511 523 530

115 249 536

115 117 249 252 536 542

118 255 549

100 110 115 118 120 220 240 249 255 258 470 510 536 549 556

121 261 562

121 123 261 264 562 569

124 267 576

121 124 126 261 267 271 562 576 583

127 274 590

127 129 274 277 590 597

130 280 604

120 127 130 132 270 274 280 284 560 590 604 612

133 287 619

133 135 287 291 619 626

137 294 634

133 137 138 287 294 298 619 634 642

140 301 649

140 142 301 305 649 657 147 316 681

147 149 316 320 681 690

150 324 698

147 150 152 316 324 328 681 698 706

154 332 715

154 156 332 336 715 723

158 340 732

150 154 158 160 330 332 340 344 680 715 732 741

162 348 750

162 164 348 352 750 759

165 357 768

162 165 167 348 357 361 750 768 777

169 365 787

169 172 365 370 787 796

174 374 806

150 160 169 174 176 330 360 365 374 379 680 750 787 806 816

178 383 825

178 180 383 388 825 835

182 392 845

178 182 184 383 392 397 825 845 856

187 402 866

187 189 402 407 866 876

191 412 887

180 187 191 193 390 402 412 417 820 866 887 898

196 422 909

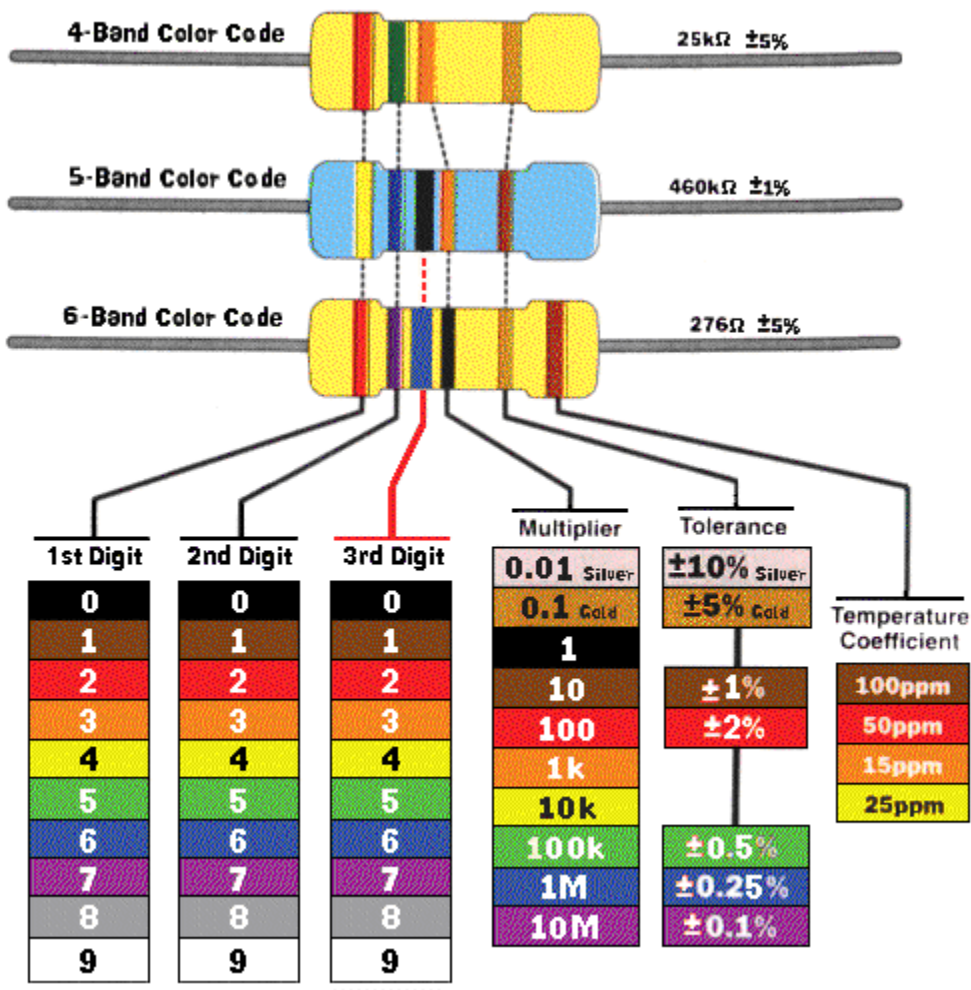
196 198 422 427 909 920

200 432 931

196 200 203 422 432 437 909 931 942

205 442 953

205 208 442 448 953 965



A free tool can be found at www.Schematica.com that helps decode the markings on resistors.

1-2 Resistor Networks (Array)

Application: This type of resistor is used when a large number of resistors with the same resistance are required, while enough space is not available or we want the circuit to have a nice appearance. **Main Specifications:**

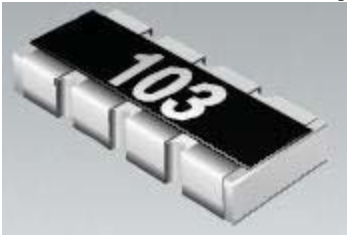
- Resistor Networks are available in SMD and DIP types. The DIP type is available in Single-In-Line (SIL) and Dual-In-Line (DIL) models.
- Resistor Networks are made with various internal constructions, such as the single-terminal (one terminal shared by all resistors), isolated (each resistor between two separate terminals), or the series models.

- Generally, the power of resistor networks is between 1.16 and 1.2 W, while having a tolerance of 1~5%, 4.7~10 R, and a thermal coefficient of 100~250 ppm.
- A variety of networks including two to tens of resistors are offered by the manufacturers. **Parameters:** Resistance, power, tolerance, internal network structure, number of pins, single-line or dual-line.

Related Pictures:



Array (Dip)



Array (SMD)

Some manufacturers: TY OHM, BC Component, Vishay, Bourns, etc.

Markings: Often, the resistance value is stamped on SMD resistor networks.

On DIP resistor networks, sometimes only the resistance and sometimes only the part number are inscribed.

Function: Rheostats are variable, high-power resistor.

Application: Often used for testing or as a load.

Main Specifications:

- Rheostats are manufactured in cylindrical (linear) and circular types.
- The power of the rheostat may be between 10 and 1000 W.
- The resistance of the rheostat is often in the order of 4.7 R ~ 10 KR.
- The tolerance of rheostats is often around 10%.

Important Parameters: Resistance, power, tolerance, shape, dimensions.

Related Pictures:



Some manufacturers: TYCO (CGS), Vishay, Ohmite, TY OHM

Markings: The power value is often printed on the casing.

Function: Variable, low-power (below 10 W) resistor.

Application: This type of resistor is used in the circuit for accurately adjusting the resistance. **Main Specifications:**

- Based on function, these resistors are classified as: Multi-turn, Single-turn, Slide

- The most important classes are:

- * Round or Slide types

- * DIP, SMD

- * Multi-Turn and Single-Turn

- * PCB mount, Panel mount, or wire output

- * Top adjust and Side adjust (with respect to the terminal)

- * Terminal layout

It is essential to have an understanding of these characteristics to make the right choice regarding trimmers.

- Multi-turn trimmers with different number of turns (4 to 25), a resistance of 10 R~ 10 M, and a power of 1~1.8 W are available.

- The single-turn trimmer can offer a range of resistance from 10 R up to around 10 MR.

- Generally, the models that do not have a shaft are called Trimmers.

- Meanwhile, the models that incorporate a shaft are called Potentiometers.

- Wirewound potentiometers can offer up to around 10 W of power.
- The resistance may be increased or decreased either linearly or logarithmically (often in potentiometers).
- Potentiometers are often manufactured in panel mount configurations.
- The tolerance is often around 10%, however, there are precision models that offer a tolerance of 1~2%.
- Some potentiometers have an On/Off switch at the start of their revolution.

The shafts of the potentiometers are made in flatted (semi-circle with one flat side), screw drive (notched), two-side flatted, and round shapes.

- The potentiometer shaft may be made of metal or plastic.
- Variable resistors can be found in various shapes and colors with metal or plastic packages.
- Some potentiometers incorporate two parallel, similar resistor banks that are called Gangs.
- There are some military-grade potentiometers, but many of them are sealed which can imply they incorporate sealed shafts, casing, terminals, or are entirely sealed.
- Multi-turn potentiometers allow for a more accurate adjustment of the resistance compared to single-turn models.

Important Parameters:

Trimmer: Resistance, power, tolerance, terminal configuration, adjustment method, single- or multiturn, output terminal type, terminal layout.

Potentiometer: All the abovementioned parameters, plus the number of banks (Gangs), the shaft configuration and material, linear or logarithmic, incorporation of On/Off switch. **Related Pictures:**



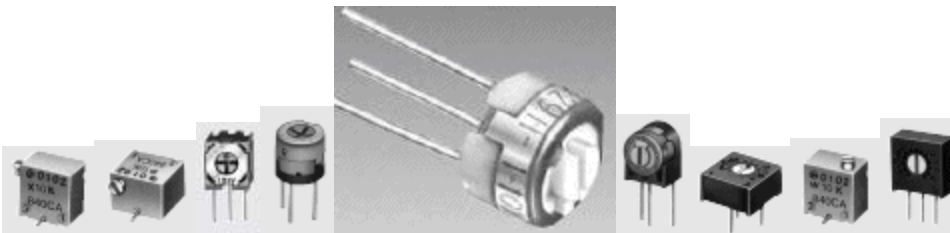
Potentiometers



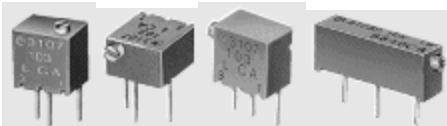
Trimmer



SMD multiturn



Single turn



Multi turn Some manufacturers: Bourns, Vishay, Alps, Tyco, Murata
Markings: Often, the resistance and tolerance are imprinted on the casing. Sometimes, potentiometers have their power and whether their linear or logarithmic nature printed on them. The multi-turn type often get printed the name of the manufacturer on its casing too.

Function: Their resistance varies with light. In fact, these components are light sensors. **Application:** Often used in the switch circuits of automatic night lights (for example at sunset). **Main Specifications:**
 - An important parameter of LDRs is their dark resistance which is their resistance in complete darkness.
 - The LDR resistance and ambient light are in an inverse relation.

- They are often made of Cadmium Sulfide.

Important Parameters: Diameter, dark resistance, light response curve, light response time. **Related Pictures:**



Some manufacturers: Photonic detectors Inc.

Markings: Often get printed no markings.

Function: Their resistance varies based on changes in the temperature. In fact, thermistors are temperature sensors.

Application: Often incorporated as temperature or current sensors, or circuit guards. **Main Specifications:**

- Thermistors are available in two types:

NTC: Negative Temperature Coefficient

PTC: Positive Temperature Coefficient

NTC: Their resistance is reduced as the temperature rises.

PTC: Their resistance is increased as the temperature rises.

NTCs are generally used in two applications:

1. Measuring the temperature limiting the Inrush current.

- The first type offers a high resistance (up to many Mega ohms) while the current-limiter provides a typical resistance of 100-200

- The dimensions of the first type are usually very small, but given the high current passing through the second type, the diameter of its disk can reach up to 15 mm.

- The most important characteristic of thermistors is their resistance at 25 °C. For example, when the resistance of the NTC is said to be 100K, it means that its resistance is 100 KR at 25 °C.

- Thermistors can be found in a range of tolerance from 1~20%.

- Another important characteristic of the NTC is the B (beta) parameter, which shows how the resistance curve is affected by temperature.

- PTC thermistors have three main applications:

- Overload Protection
- Temperature Sensing
- Time delay

- For the overload-protection type, the allowable internal current is important, and changes in the current are associated with changes in the resistance. The temperature-sensing type is more sensitive to changes in the casing and ambient temperature. The time-delay type, which is often incorporated in low-consumption lamps does not impede the current at first, but its resistance rises rapidly after a certain length of time (i.e. 5 seconds).

Important Parameters:

NTC: R25 value, tolerance, B (beta), application, current (for the Inrush Current type).

PTC: R25 value, tolerance, application.

Related Pictures:



NTC:



PTC

Some manufacturers: EPCOS, Philips, Murata, Rhopoint

Markings: Often the resistance and tolerance are printed on the casing if the component dimensions allow it, otherwise (if the components are too small), nothing is printed.

Function: Normally, below the breakdown voltage, their end-to-end resistance is almost infinite, however, above the breakdown voltage, the resistance falls rapidly to almost zero. **Application:** Generally used for voltage protection at the circuit input.

Main Specifications:

- Varistors are available for both AC and DC applications.
- The larger the varistor diameter, the higher its energy.

Important Parameters: Voltage, tolerance, diameter.

Related Pictures:



Some manufacturers: EPCOS, Littelfuse, Hitano

Markings: Generally, the voltage, tolerance, and the diameter are stamped on the casing. Capacitors are classified into a few important groups:

1. Fixed
2. Array
3. Trimmer
4. Three-Terminal Capacitor (will be discussed in the section dedicated to filters)
5. Feed-Through Capacitor (will be discussed in the section dedicated to filters)

Function : A capacitor is made of two energy-saving plates with an insulation in between, and stores energy (voltage) between the two plates.

Application: Bias circuits, decoupling, separator, filter, bypass, etc.

Main Specifications:

- The capacitance is specified by Farads (F). However, Farad is a large unit and capacitors are often associated with a capacitance of few tenths of picofarads to few millifarads.

1 PF = 1 picofarad = 10^{-12} farad

1 NF = 1 nanofarad = 10^{-9} farad

1 UF = 1 micro farad = 10^{-6} farad

1 MF = 1 millifarad = 10^{-3} farad

- In the Japanese standard, capacitor voltages are represented by the following letters: **Voltage (V)** 50 63 100 125 160 200 250 400 630 1000 1500 **Standard symbol** 1H 1J 2A 2B 2C 2D 2E 2G 2J 3A 3T

Typical Pitch: {2.5, 3, 4, 5, 6, 7.5 , 10, 15, 22.5 mm}

The dimensions of SMD capacitors are often in compliance with the

standard and the descriptive table presented at the end of this book (the SMD component case calculations).

- Sometimes, the operating temperature is indicated in accordance with the IEC standard as in the following example:

55 / 105 / 26

Which means that the operating temperature is: $-55 \sim +105$

- The capacitance is in compliance with E24 and E96 standards that have been covered in the chapter dedicated to resistors.

2-1 Fixed Capacitor

- Fixed capacitors are available in a variety of models, the most important of which are compared in the table below. (Notice: ppm=part per million)

Capacitor Type

Advantages

Polystyrene (KS)

Very small dissipation factor

Low TC

Disadvantages Low solder ability

Polypropylene (KP)

Low dissipation factor, excellent impulse response, low

loss

Large

dimensions,

highly priced

Polyester (KC)

High operating voltage Acceptable impulse response

Acceptable stability

Polycarbonate (KC)

Acceptable stability

Low TC

High Thermal Coefficient (TC)

-

Thermal Coefficient (ppm/°C)

"-150ppm" "-200ppm" "+500ppm" "+150ppm"

Capacitor Type

Metalized

**Polycarbonate Capacitor
(MKC)**

Advantages Low TC and price

Disadvantages

Range of

Capacitance Range of

Voltage

Range of

Tolerance

Thermal

Coefficient (°C/ppm)

Large dimensions, higher price

Compared to Polyester

1n~10U

Metalized

Polypropylene Film (MKP)

Very small dissipation factor, favorable pulse resistance

Large dimensions, higher price

Compared to Polyester

100p~10U

Metalized Polyester Film (MKT)

Favorable selfimprovement

1n~10U 16V~1KV 160V~6KV 16V~1KV 5% ~ 20% 5% ~ 20% 5% ~ 20%
"+150ppm or ±100ppm" "-200ppm" "+400ppm"

Construction Film electrodes that have been metalized on both sides

Film electrodes that have been metalized on both sides

Film electrodes that have been metalized on both sides

Capacitor Type Wet Tantalum

Advantages

Disadvantages

High

capacitance

High price

Titanium - Magnesium Ti-Mg

High

operating

voltage, high frequency

Low

inductance, Hi-Q

High price

Range of

Capacitance Range of

Voltage

Range of

Tolerance

Thermal
Coefficient ppm/°C

10U~1.8m 1p~2.2n

Tantalum

Aluminum Electrolytic

Silver Mica

High capacitance with small
dimensions, low price, low leakage current

High capacitance with small
dimensions, low price

Short life at high temperature,
costlier than
electrolyte

0.1U~1.5m
25~125V 500v~ 2KV 2.5~50V 10~20% 5% ~20% 5% ~20%

Short life,
especially at high temperature, high leakage current

0.47U~680m
6.3~450V
10% ~ 20%

±1000pp m
"±100ppm" "±1000ppm"

Construction Porous Tantalum tablet with
electrolytic filler

1000~10000ppm

Oxide layers as dielectric between aluminum plates with
electrochemical function
High

stability,
accurate,
acceptable impulse
response

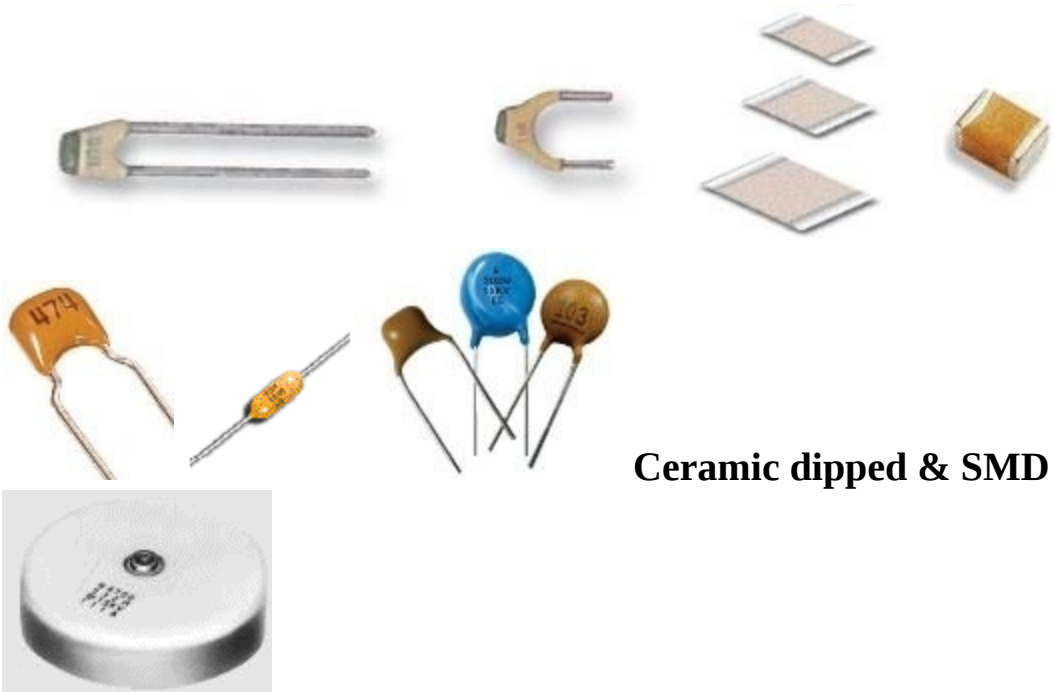
High price, large
dimensions

1P~82n
50V~1kV
1% ~ 10%

Less than 200 ppm

Silver layer applied on both sides of a mica plate

- **Fixed capacitors are classified into eight main groups:** 1. Ceramic With COG, (NP0), X7R, Y5V, Z5U, BP, and BX dielectrics whose characteristics were presented in the previous table.



Ceramic dipped & SMD

high voltage mold type capacitor
Capacitor Type

BP ceramic BX ceramic

Advantages

Y5V, Z5U ceramic

High

capacitance for medium sizes, low price

X7R ceramic

(NP0)

(COG) ceramic

Very low thermal coefficient

Disadvantages

Range of

Capacitance Range of

Voltage

Range of

Tolerance Thermal

Coefficient ppm/°C

Similar to

X7R and

(NP0)but

with a

tolerance of 10~20% and Military grade

characteristics Similar to

X7R ceramic but with

military-grade characteristics

120P~ 22U 100P~10U

Limited

range of

capacitance, high
capacitance types are
expensive

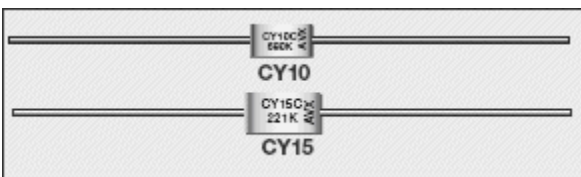
0.3P~330N
16V~250V 16V~10KV 16V~10KV
> 20% 5%~20% 1% ~ 10%
"±10,000ppm" "±1000ppm" 0~30ppm

Construction Thin film
coated on
ceramic plates Thin film
coated on
ceramic plates Thin film coated on ceramic plates

- Round disk capacitors with COG dielectric. This type of capacitor is becoming obsolete and replaced by multilayer ceramic capacitors.
- Military-grade ceramic capacitors have a standard number (often M39014) and something similar to the following code inscribed on them: M39014 / 01 XXXX

The last four letters, showing the characteristics, can be identified using the standard tables corresponding to this group. For example, M39014 / 01 1594 indicate a capacitor of 100n, 50V, 20%, and a Failure rate of 0.001. The same capacitor is represented by CKR05BX104MS in the AVX standard,

2. Ti-Mg (Titanium - Magnesium) and Glass For high-frequency and high-voltage applications and often Hi-Q (similar to **NP0** and X7R in general characteristics).



3. **Silver-Mica:** For precision and high-voltage applications (often conforming to military-grade and standards application).



4. Polyester General application (this type of capacitor is gradually becoming obsolete).

5. **Metalized** With polyester, polypropylene, polycarbonate, and polystyrene dielectrics.

5-1 Metalized Polyester General application and decoupling and bypass



5-2 Polypropylene Radio interference suppression. This group generally includes three subcategories:

Y Class: Designed for grounding a current carrying conductor.



X1 Class: For connecting current carrying conductors (phase to phase, or phase to neutral). These capacitors increase the range of impulses and can be applied where very high transient states are needed.



X2 Class: For connecting current-carrying conductors (phase to phase, or phase to neutral) for general applications and where a transient state is not desired.

This class of capacitor is similar to X1 in appearance with the only difference being that it gets printed the X2 sign.

- The Polypropylene-Sulfide (PPS) capacitor is used for stability and working at temperatures above 125 °C.

5-3 Polycarbonate: This type of capacitor features fixed thermal effect.

Application: in filters, memories, timers, and balance capacitors.

6. Tantalum

- These capacitors are available in DIP and SMD models and bubble-shaped, cubic, and axial configurations.

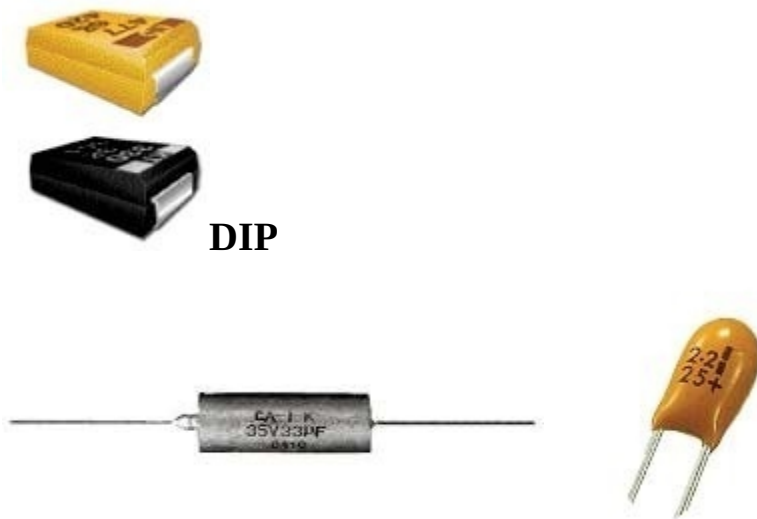
- Military-grade Tantalum capacitors have a standard number (often M39003) and something similar to the following code inscribed on them: M39003 / 01 XXXX

The last four letters, showing the characteristics, can be identified using the standard tables corresponding to this group. For example, M39003 / 01 2290 indicate an axial capacitor of 15U, 20V, and 20% tolerance.

- Tantalum capacitors are much more expensive than their electrolytic counterparts, however, both of these capacitors are directional and the SMD models of these capacitors have their positive side indicated by a band.

- Tantalum capacitors generally feature a low capacitance (up to 100U / 35V) and their high-voltage, high-capacitance models, manufactured by Kemet and Vishay, are quite expensive (around 50\$).

SMD



7. Electrolytic capacitors

- Electrolytic capacitors have wet materials and their capacitance is the result of a chemical reaction between their two electrodes. These capacitors are often associated with a very high capacitance (1 F ~ 10,000 F). The operating voltage of these capacitors is also in 25~630 V. These capacitors are larger than the other models in size. Even the dimensions of their SMD models does not depend on the SMD Case tables and they generally have a cylindrical shape.
- Their tolerance is often around 20%, but rarely manufacturers produce capacitors with 10% tolerance.
- Their lifetime is short (around 2000-5000 hours, with some cases reaching 10,000-12,000 hours).
- Typically, the operating temperature of this type of capacitor falls in the range 0~70, -25~85, 040~85, or -55~105.
- The terminals of the larger capacitors are often short and wide. Moreover, the band on the package marks the negative side of the capacitor.
- Electrolytic capacitors can be found for various ranges of temperature; however, a great disadvantage of these capacitors is that their capacitance changes considerably at higher temperatures. Moreover, high temperature promotes leakage current and shortens their life. Therefore, in such cases, Tantalum capacitors are used that are more stable and have a longer service life.

Axial



Radial



8-Memory backup

Radial:



SMD :



- These capacitors are often associated with a very high capacitance and low voltage (e.g. 1 F, 5 V). They retain the voltage excellently and are good choices for replacing some batteries in memory circuits.
- These capacitors often feature very small dimensions.

Variable capacitors are often used in filters and are generally made of ceramic.



Trimmer capacitor



Variable capacitor

These networks integrate a number of capacitors in a package and are often made of ceramic.



Typical Pitch: {2.5, 3, 4, 5 6, 7.5 , 10, 15, 22.5 mm}

The dimensions of SMD capacitors are often in compliance with the standard and the descriptive table presented at the end of this book (the SMD component case calculations).

- Sometimes, the operating temperature is indicated in accordance with the IEC standard as in the following example: 55 / 105 / 26

Which means that the operating temperature is: -55 ~ + 105

Important Parameters:

Fixed Dual In-line Package (DIP) Capacitors: Capacitance, voltage, tolerance, pitch, configuration (radial or axial), dielectric material.

Fixed SMD Capacitors: Capacitance, voltage, tolerance, case dimensions, dielectric material. **Electrolytic:** Capacitance, voltage, pitch, configuration (radial or axial), dimensions, operating temperature, terminal type.

Tantalum: Capacitance, voltage, tolerance, pitch, capacitor shape, dimensions, configuration (radial or axial).

SMD Tantalum: Capacitance, voltage, tolerance, case.

Capacitor Network: Capacitance, voltage, tolerance, number of capacitors, number of terminals, dielectric material.

Variable Capacitor or Trimmer: Minimum and maximum capacitance, voltage, body shape, terminal shape, adjustment method (from top or side).

Related Pictures: Presented separately for each type of capacitor.

Manufacturers:

- Ceramic and Tantalum capacitors: AVX, Kemet, Novacap, Vishay, Philips
- High-capacitance Tantalum capacitors: Vishay, Kemet
- Cubic Tantalum capacitors: Vishay
- Mica capacitors: SAHA (Sharma), CLEC
- Ti-Mg capacitors: Morgan
- Glass capacitors: AVX
- Metalized capacitors: Philips, Wima, Vishay, EPCOS
- Electrolytic: Rubycon, Elite, Panasonic, Philips, Panasonic, Elna: -
Memory backup
- Capacitor Network: AVX, Murata
- Trimmer capacitors: Johanson, Philips, Murata, AVX

Markings: The markings on capacitors are often in the form of numbers, with the most common of them as follows:

102K200 = 1n, 10%, 200V

Equal with: The first and second numbers represent themselves but the third one is the number of zeros, therefore:

102= 1000pF =1nF

0.01/ 5/63 = 10n (0.01 F), 5%, 63V

0.47J200 = 470n (0.47 F) , 5%, 200V

4n7K 200 = 4.7nf , 10% , 200V

1.0K100 = 1 F, 10% , 100V

(Voltage, according to the Japanese standard) 0.47 K1J=470 n (0.47 UF), 10%, 63V (Given the wide variety of models, each class is investigated separately) The classes addressed are:

1. Inductor 2. Transformer 3. Core 4. Bobbin 5. Core Holder 6. Filter

Function: A coil that is wound around an insulator and resists the current variations. **Application:** Filter circuits, current damper

Main Specifications:

- Inductance is measured in Henrys (H). However, Henry is a large unit and the inductance value is generally a few nano-Henrys up to 1 H.

1 nH = 1 nanohenry = 10^{-9} Henry

1 H = 1 microhenry = 10^{-6} Henry

1 mH = 1 millihenry = 10^{-3} Henry

- Inductors are available in a wide variety of models (DIP or SMD) with the major groups being: Fixed air core inductor

Fixed Radio Frequency Choke (RFC)

Fixed ferrite bead inductor

Fixed radial inductor

Fixed coil-former (with standard core)

Fixed toroidal-core inductor

Suppression choke

Variable coil

- Inductors are made in coated and uncoated (visible coil) types.

- Their inductance tolerance is often 5, 10, or 20%.

- The Self-Resonance Frequency (SRF) and the Idc current decrease as inductance is increased.

- The fixed radial inductors are also available in bubble-shaped and cubic types in addition to cylindrical.

- The fixed coil-former inductors are wound around various coil-formers and cores (such as E, RM, etc).

- Variable inductors are available in Molded (without shield) and Shielded types.

- Some variable inductors incorporate an internal capacitor between their terminals.

- Variable inductors are available in two different models with respect to adjustment method: one-way (from top), and two-way (from both top and bottom).

- Some variable inductors have a distinct color to distinguish them in the circuit and help users or technicians make correct adjustments.

- Some variable inductors are made for special IF frequencies (e.g. 455 KHz).

- SMD inductors are often made in standard sizes complying with SMD size standards mentioned at the end of this book.
- The operating temperature of inductors is sometimes indicated by the IEC standard, for example as "26/55/105" implying: Operating temp: -55 ~+105 °C
- The inductance is often in compliance with the E24 standard which was covered in the section dedicated to resistors.
- Fixed resistor-shaped inductors are marked with the same color bands as resistors. If one of the bands on the side is silver and is double the width of the other bands, the inductor is, undoubtedly, military-grade, and the band is not taken into account when calculating the inductance. However, the inductance is found in H using the color tables presented on Page 17 (this method is becoming obsolete). In more recent methods, the color bands are similar to resistors.

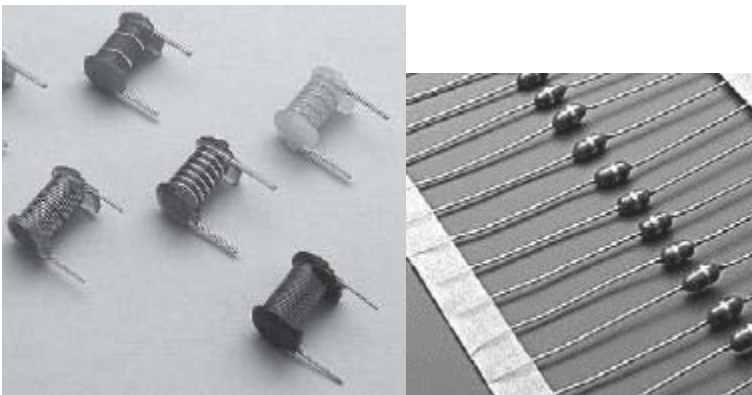
Important Parameters:

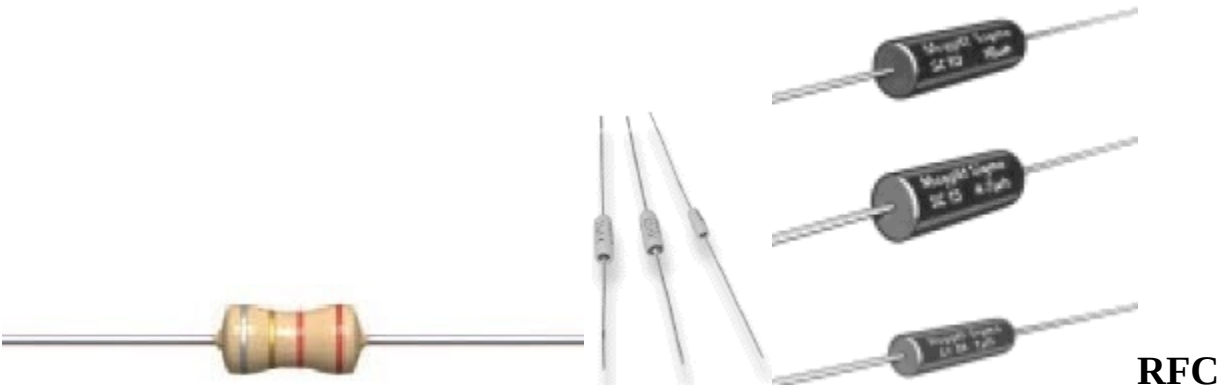
These parameters are shared by most fixed inductors:

Inductance, tolerance, pitch for DIP or case for SMD, SRF frequency, I_{dc} current, core dimensions (for inductors incorporating a bobbin or those with a toroidal core).

Variable Inductors: Central inductance, tolerance (range of variation), the package (metal or plastic), dimensions, test frequency, internal capacitor, adjustment method (two-way: from top and bottom, or one-way), number of turns. **Related Pictures:**

Fixed inductors:





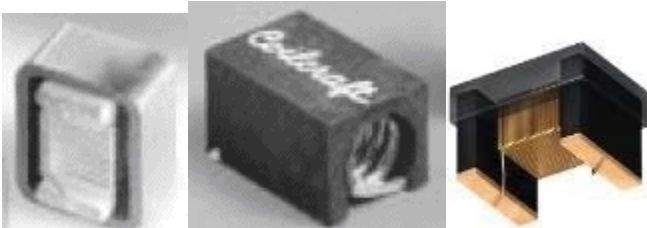
RFC



Wound bead



Radial



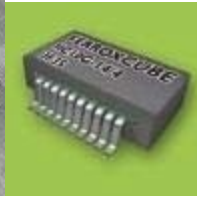
SMD FIXED



Rod core chokes



smd and THD drum



RFC



RFC

Inductor with toroid core

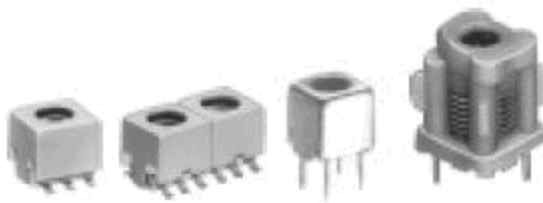


Twin chokes



Suppression choke

Variable (Tunable) Inductors:



Some manufacturers:

TOKO, Fastron, Neosid, Sigma, API, Epcos, Coilcraft, Murata, Vogt

Markings: In RFC models, color bands are used to indicate the inductance or tolerance (the chapter dedicated to resistors covers the implications of these color bands and how to read them), or the inductance, tolerance, and part number are imprinted on the inductor. In other fixed inductors, also in the SMD models, often either the part number is fully or partially imprinted or markings are entirely left out. The variable inductors incorporated in a metal-casing often bear the part number and sometimes the manufacturer them. Molded variable inductors often have no markings.

3-2 Transformers

Function: Transformers are often made of two or more coils laid on top of each other (or side-by-side) with a shared core, enabling the induction of the magnetic field from one coil to another. **Application:** Voltage transformation (step-down or step-up), current transformation (step-down or step-up), impedance matching circuits, current-to-voltage transformation (current sensor), etc. **Main Specifications:**

Transformers are often available in the following models:

Audio (Audio impedance matching)

Current:

Matching (including ISDN, T1, E1 (CEPT) groups):

Normal

Pulse

Variac

Auto-transformer

- **Audio Transformers:**

Often used for reinforcing the amplitude or the power of the sound and matching. These transformers are available with various ferrites E, toroidal, and iron cores.

- Their operating frequency is in the range of audible frequencies and their impedance is a few hundred Ohms. Their secondary and primary DC

resistance varies from a few Ohms to a few hundred Ohms.

- Current Transformer or Current Sensor:

This type of transformer is often used for identifying and measuring the current. Current transformers are often toroidal with the primary winding being the current-carrying wire that passes through the hole in the middle of the loop and the secondary coil is wound around the core. Current passing through the primary winding leads to current variations, and consequently voltage, between the two ends of the secondary coil.

ISDN Transformer

The ISDN line is used for communicating information and protocols in long distance (up to 5 km). It is mostly utilized in military applications and matches military-grade wires.

- Normal Transformers:

- Typical step-down or step-up transformers with the step-down models being more commonly used.
- The most common types of these transformers have a primary voltage of 110 or 220 V and a secondary voltage of 3, 6, 9, 12, 16, etc. Their input can even be composed of two coils

(E.g. 2x110 Vac) and the output, or the secondary coil can generate variant voltages. For example: 220/3, 6, 9V

- These transformers often incorporate iron cores with the EI models being the most common. However, transformers with toroidal cores are also manufactured that offer a much higher efficiency compared to the EI models.
- The operating frequency of these transformers is also generally less than 1 kHz.
- Generally, there are two wires for each output voltage. However, sometimes, one wire is shared by multiple outputs.
- From the matching transformers, the ISDN transformers are used for 30/2 sampling, E1 transformers for 30/30 sampling, and T1 transformers for 30/24 sampling from telephone lines in Time Division Modulation (TDM) mode.

Pulse Transformers:

These transformers are used for transmitting pulses. Given their higher operating frequency compared to normal transformers, if the input is a pulse, the output would be in a similar shape.

Important Parameters

Audio Transformers: Core shape and dimensions, operating frequency range, secondary/primary

power.

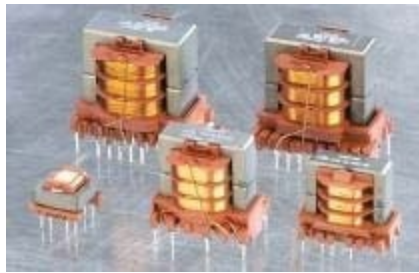
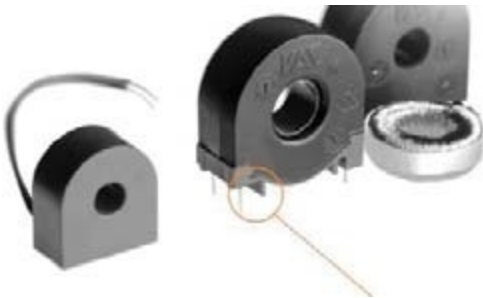
Current Transformer: Transformation ratio, charge resistance, wire hole diameter, installation method, maximum sensible current.

current. indings, secondary volt-ampere, dimensions, tolerance, output voltage

Pulse Transformers: Transformation ratio, dimensions.

Related Pictures:

Current transformer



Switching power

supply transformer



Ballast Transformer



Audio



Isolating



Pulse

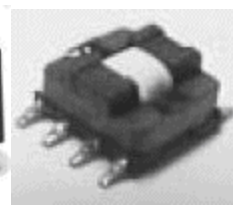
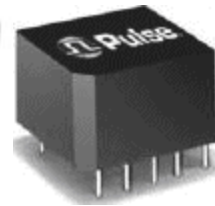


transformer)

Variac (Variable



Auto transformer



Transformers Some manufacturers:

Audio transformers: PICO, Bourns

ISDN transformers: Bourns, Bestwindings

Current transformers: Thousands hundred, Bestwindings

Normal transformers: All manufacturers

Cooper Bussmann, Pulse, Bestwindings: Pulse

Markings: Often get printed the name of the manufacturer and the part number. Some transformers also have their transformation ratio, and sometimes the connection method for the coils, imprinted on them too.

3-3 Cores



Function: Cores are used to wind coils and are made of plastic, metal, iron powder (ferrite), wood, or even air. Here, we examine ferrite cores.

Application: Used for winding inductor or transformer coils.

Main Specifications: The following are the most common types of cores:
3 1. Bead and Multi-aperture



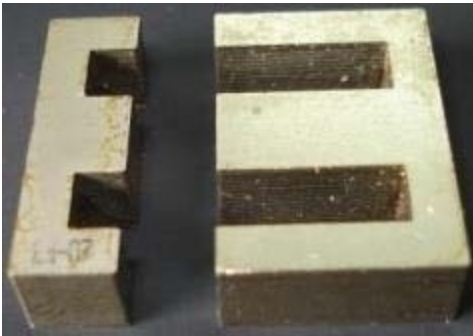
3-2: Standard Shapes:

3-2: Standard Shapes:

planar E core with recess :



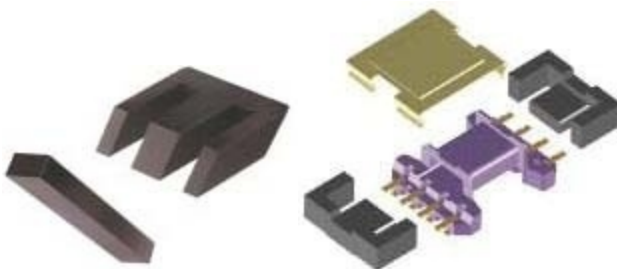
E core :



E with coil-former:



EI :



EFD :

ETD :



ER :



EP :

EP/LP :



EPX :

3-2-2: P , OP , PC , RM:



PM :

EQ :



Planar ER :

PQ :



PT :



PTS :



RM :

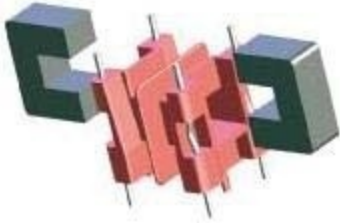


RM/ILP:

P :



3-2-3:U, UI , UH , UR

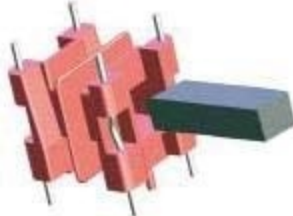


U :

PH :



I: P/I :



3-2-4:DH , OSH , DRH , R , TH , THP , DR (1 , 2 , WW1 , WW2 , WW3) , RH , CBH- C , RI , ST, SP , SDR , H , L , C , AP

3-3 Round and flat cable suppression core



3-4 Special shape and Models



frame and bar cores

3-5 Toroidal



- The first group comprises cores with one or more apertures.
- All cores above are made in different sizes.
- i is an important parameter for every type of core.
- Any of the above-mentioned cores can be made with various i values for different applications.
- The higher i , the lower the operating frequency of the core.
- The names of the E-shaped cores (for example E25) indicate their height.
- Even for a common i , manufacturers use their own material name.

Therefore, similar cores can be found in products of different manufacturers.

- The 3-3 series is used for noise suppression in the round and flat cables. These cores are coiled around the cable and then locked.**
- The fourth group comprises all non-standard shapes that are custom-made for a specific customer or application.**
- The fifth group, the toroidal, is one of the most common types of cores that offer a high efficiency in different applications due to their loop-like shape. These coils are available for normal (a few Hz) to Radio Frequencies (RF).**
- EI, EE, and toroidal cores are used for making normal 50 Hz mains transformers (with iron, iron powder, etc. cores).**
- Some cores must be installed on coil-formers (bobbins), such as the E, RM, and the U series.**
- Some of the cores above can be used without coil-formers, such as toroidal or bead cores.**
- Some of these cores (such as the RM series) must be fastened by yokes or clips.**

- Some of these cores (such as the E or RM series) can be ordered either with or without an air gap in the middle.

- Some cores, such as the RM series, have some accessories, such as an adjustment screw, or an insulator.

Important Parameters: Standard shape (or model), dimensions, core material code (knowing the manufacturer is necessary).

Related Pictures: In the last three pages.

Some manufacturers: YTE, EPCOS, Neosid, Vogt, Fair-Rite

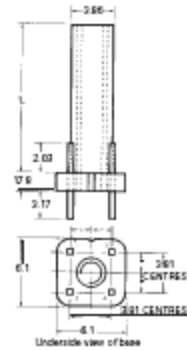
Plastic, wooden, or metallic pieces on (or in) which the cores are installed, and the coil is wound. Main Specifications:

- Coil-formers are available in normal or SMD terminal models.**
- Often, the standard shape of the core must be known so the suitable coil-former can be selected.**
- Some coil-formers allow multiple coils to be wound separately at different levels.**
- Coil-formers are available in different colors. However, this does not**

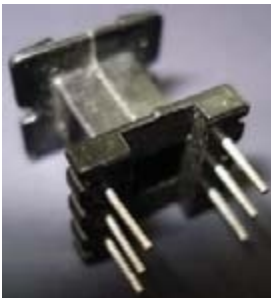
- Coil-formers are often made in two models. In one model, the coil is positioned horizontally while in the other one, it is oriented vertically (pictures below).



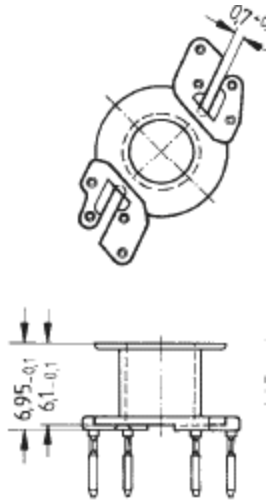
Related Pictures:



TREADED



EE



RM Moreover, examples of most coil-former models can be found in the ferrite core section.

Some manufacturers:

EPCOS, Kashke, Ferroxcube, etc.

Markings: Often without markings.

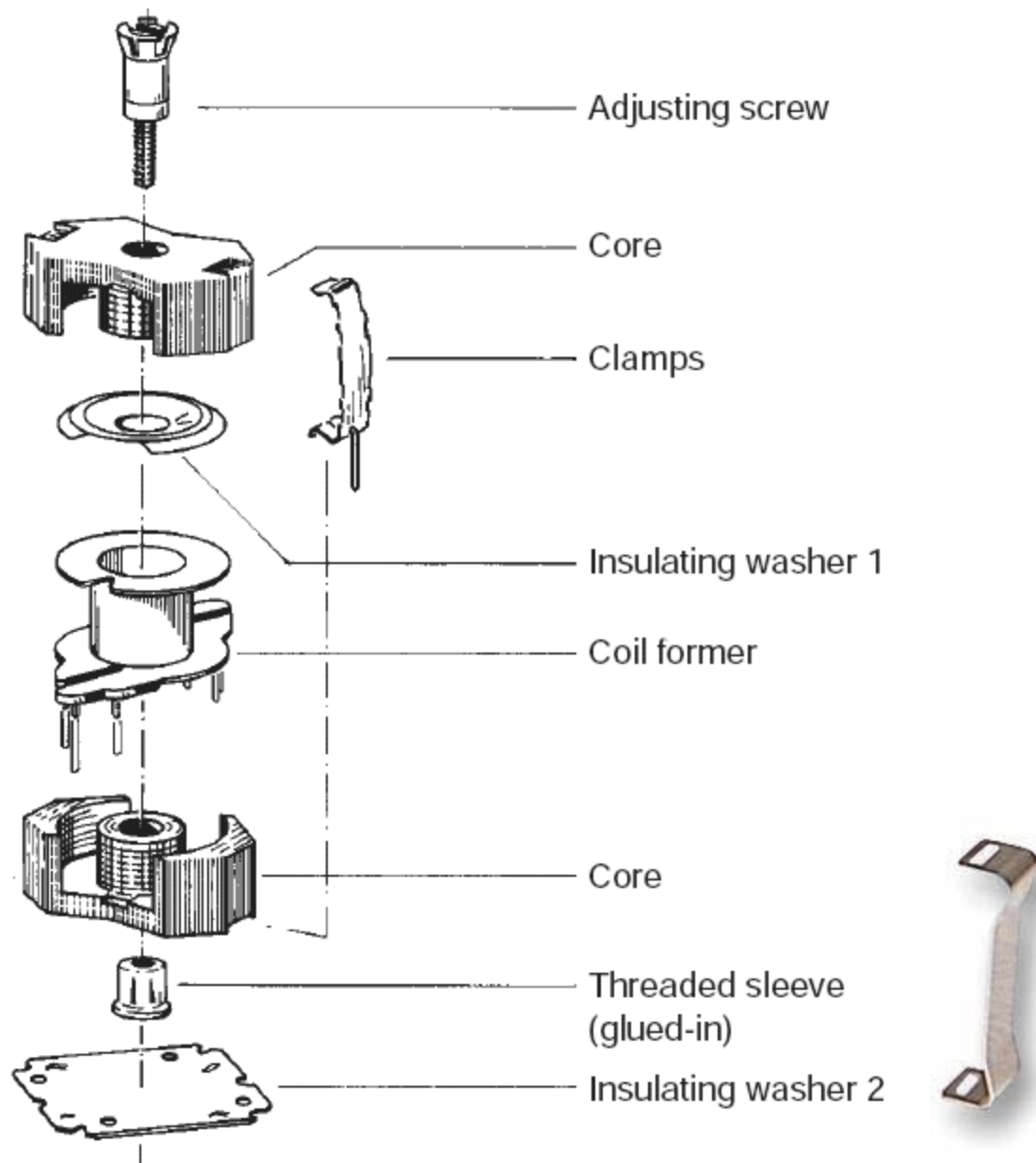
Metal components used for holding the two parts of two-piece cores.

Main Specifications:

- Generally, two types of holders are made, either for ferrite or iron cores.
- Each type of holder is only applicable to its corresponding core.
- E and RM cores often incorporate a holder.
- Some cores require two holders, such as the RM series. For example:
RM
- Some holders have a terminal that provides additional robustness for the connection of the core on the board.

Important Parameters

The type of the corresponding core, and incorporation of a reinforcement terminal. **Related Pictures:**



CLIP OR YOKE

Some manufacturers:

EPCOS

Markings: No markings.

Filters are used for transmitting some frequencies while suppressing the rest and are extensively applied to all electronic circuits.

A filter can have a simple structure with passive components such as inductor, capacitor, and resistor, or a complex structure incorporating as integrated circuits (IC) and crystals.

Main Specifications:

Filters are available in different types (discrete, hybrid, incorporating connectors, etc.).

- **There are no frequency restrictions for filters and they can be made for DC voltage (0 frequency) up to many GHz frequencies.**

- **The most common filters are as follows (The name of the manufacturer is shown in parentheses): 3-Terminal Capacitors (Murata)**

Duplexer (Murata)

Feed Thru Capacitors (Murata and Tusonix)

Equipment EMI Filters or IEC PLUG Filters (Schaffner)

Ceramic (Murata)

Crystal (PDI)

Dielectric (Toko)

EMI (Murata)

Helical (Temwell)

Hopping (Polezero)

IF (Toko)

RC Network (Mini-circuits)

Saw (AEC)

Data line Filter (Murata)

Filters can be classified into four major groups: Low-pass, High-pass, Band-pass, and Band-reject.

- **Some frequencies are very common in filters (such as 455 kHz, 10.7 MHz, and 21.4 MHz) and are produced by many manufacturers.**

Duplexer and equipment EMI Filters series are filtering components making a complete filter in combination with other components such as inductors, and resistors.

Important Parameters

3-Terminal Capacitors: Capacitance, tolerance, frequency range

Feed Thru Capacitors: Capacitance, insertion loss at 1 GHz, installation location (package or panel), length of package, package shape.

Data line Filter: The number of data lines, maximum allowable current in the line, L/winding ratio, DC resistance (DCR), isolation voltage.

Other groups: Frequency classification, frequency, installation method, insertion loss or bandwidth. Related Pictures:



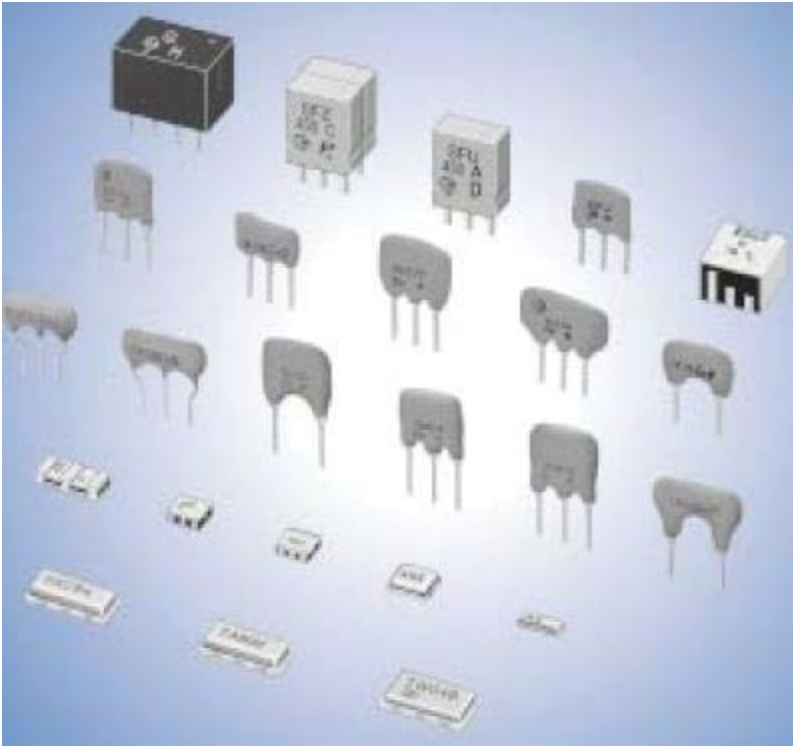
EMI filters (block, bead with lead, 3-terminal SMD, array, DIP)



EMI filters(chokes)



Feedthrou



Ceramic filter and discriminators



**Dielectric filter
& line filters**



IEC plug



Low pass filter

Semiconductors can be divided into Integrated (IC) or Discrete Circuits. Here, we examine the discrete semiconductors.

1- Diode 2- Transistor 3- LED 4- industrial-grade electronic components

Function: Diodes often have a cathode (negative terminal) and an anode (positive terminal) and are incorporated in either forward (e.g. typical diodes) or reverse bias (e.g. the Zener diode) modes.

Applications: Diodes are generally utilized as rectifiers, filters, cutters, and clampers, with the following as a few specific applications:

- Bridge diodes are often used at the circuit input for AC-DC transformation.
- Fast diodes are used as switches.
- Varactor, Detector, Schottky, and PIN diodes are often incorporated in RF circuits.
- PIN and Varicap diodes have opposite structures as the PIN diode features a small area P-N junction to reduce the capacitance for RF applications while the P-N junction area in the Varicap diode is very large to provide a high capacitance (up to 2.5 NF).
- In photodiodes, the PN junction is illuminated using a lens.
- Zener diodes are very common as voltage regulators.
- Photodiodes, Zener diodes, and Varicap diodes are integrated into circuits in reverse bias. Main Specifications: Diodes are often available in the following models:

Diode Array

Band Switching Diode

Diode Bridge*

Current Regulator*

Detector

Varactor or Varicap*

Fast Diode*

Germanium diode

Matched Configuration

Doubler

Mixer

Normal Rectifier*

Photo Diode

PIN*

Schottky*
Transient Suppressor

Zener*
Laser

*** These models are the most common.**

Main Specifications (excluding Zener diodes):

- Except for the bridge diodes that have four terminals, and diode arrays, the rest of diodes generally have two terminals.**
- The most common models are often produced by different manufacturers with the same name. For example:**

1N4001, 1N414

The symbol for the diode in the American standard is 1N, while it is 1S in the Japanese standard. The number after the symbol can be decoded with the help of datasheets.

- In the European standard, "A" in the first place indicates Germanium diode while "B" indicates a silicon diode. The meaning of the second letter: A = Rectifier, B = Varicap, Y = Power, and Z = Zener.**
- The cathode side or the negative terminal is marked with a color band.**
- Often, the SMD equivalent of a DIP diode is named differently, for example:**

DIP: 1N4001, SMD: SM4001

DIP: 1N4148, SMD: LL4148

- Some types of diodes are only available in DIP models, while only SMD models are manufactured for some other types.**

Main Specifications of the Zener Diodes:

Naming and Part no. Zener diodes are often named by the following method:

1. BZ at the beginning of the Part no: E.g. BZX55C2V4 where BZX indicates a Zener diode with DO -35 Package, 55 shows the power (500 mW), and 2V4 indicates the voltage of the Zener diode (2.4 V).

BZV is another prefix of the Zener diodes, representing the Package of the SMD Melf diodes. 2. Using an international code (1N4728 :1N Zener diode 1W / 3.3V)

- Sometimes Zener diodes are marked as C15 which is BZX55C15 (or BZX85C15).
- The casing or package of Zener diodes are often DIP (e.g. DO -35, and D0 41) or SMD (e.g. SOD-32, Mini Melf, or SOT-23).
- Some manufacturers: (e.g. Micro Semi) offer military-grade Zener diodes, distinguishing them by adding their class (JAN, JANTX, JANTXV) to the Part no.
- The black band on Zener diodes shows the negative terminal or the cathode.

Parameters: (For common diodes)

Bridge and typical diodes: Operating voltage, current

Fast and Schottky diodes: Operating voltage, current, trr (rise time)

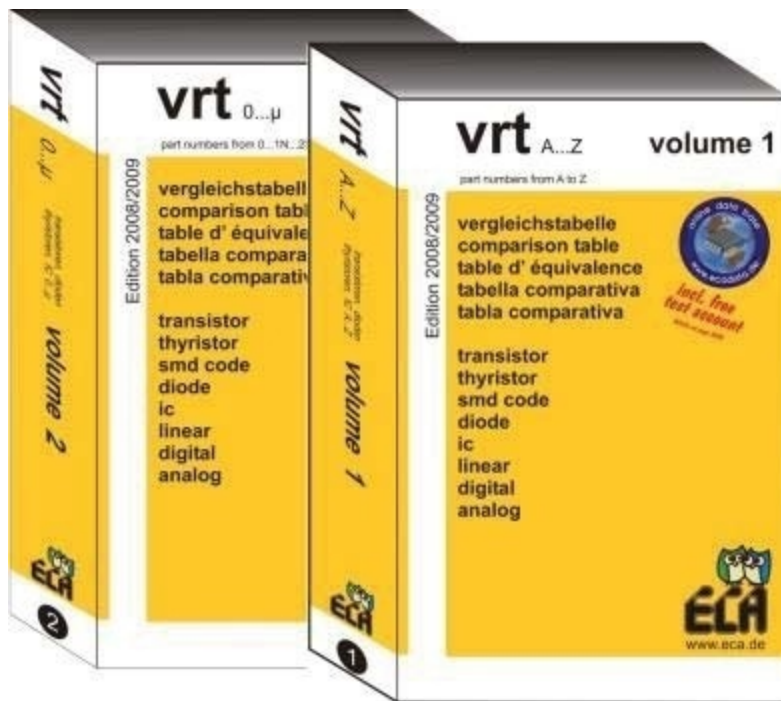
RF diodes (e.g. PIN): Operating voltage, frequency, etc.

Zener diode: Voltage, power, component shape and dimensions

The mentioned parameters are the most important ones, however, many other factors must be considered when selecting a diode.

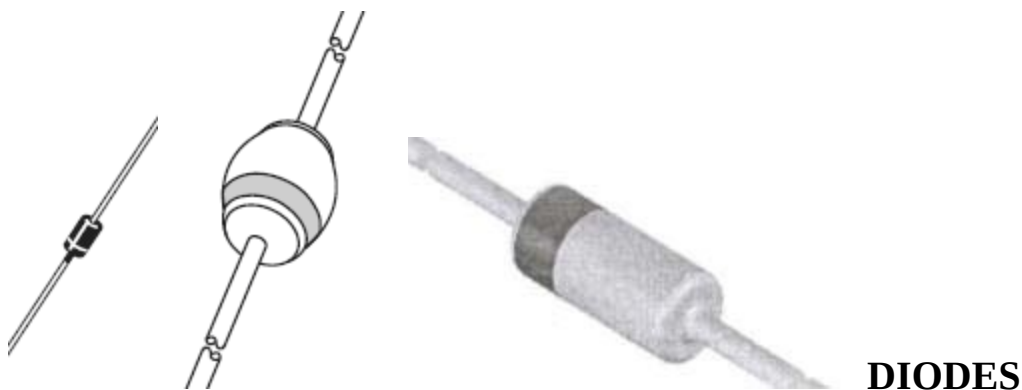
-

programs (e.g. CAPSXPRT) are available that classify diodes according to their characteristics.



ECA vrt

Related Pictures:



Laser diode

BRIDGE DIODES

High power zener



SMD PACKAGES MELF



Some manufacturers:

Typical diodes: Microsemi, Fairchild

Fast diodes: Microsemi

RF diodes: M/A COM

Zener diodes: Vishay, Microsemi, Philips, Fairchild, MCC

Markings

Component name in SMD models, sometimes without markings.

- **Generally, comprehensive markings are imprinted on diodes; however, sometimes manufacturers leave out the first letters of the diode code (e.g. 4148 instead of 1N4148). Moreover, only the voltage may be imprinted on the casing of Zener diodes.**
- **For 1N4148 diodes, color bands are also used. For example: (Resistor color bands)**
- **-5082 series diodes. For example, they use 2811 instead of 28511-5082.**

4-2 Transistors

Function: Depending on the accompanying circuits, transistors modify the current entering their common terminal by amplifying or switching it on or off.

Application: Transistors are used as current amplifiers, switches, voltage-controllers, current controllers, etc.

Main Specifications:

Transistors are often available in the following models:

BJT, Darlington, Infrared, Phototransistor, Pre-Biased Digital, PUT, UJT

- Transistors are often associated with Emitter, Collector, and Base terminals.

- Another type of transistor exists that is classified as the Field Effect Transistor (FET) and comprises Drain, Gate, and Source Terminals.

MOSFET, Dual Gate MOSFET, JFET, JFET-Dual Channel, MESFET, LDMOS, VDMOS

- In the American standard, transistors are represented by 2N, while their symbol in the Japanese standard is 2S. For example 2N2222A.

- In the Japanese standard, a letter comes after 2S, implying:

A = PNP, Hi-freq. B = PNP, Low-freq. C = NPN, Hi-freq. D = NPN, Low-freq.

- The letters in the European standard have the following implications (for example BC107): The first letter: A = Germanium, B = silicon, the second letter:

C = Low Power, Low freq. D = Hi P. Low f. F = Low P. Hi F. L = Hi P. or Hi F., S = Low P. switch application, U = Hi P. or Switch.

Military-grade transistors are often indicated by a JANTXV, JANTX, JAN prefix or suffix.

- The following are some of the most famous prefixes for transistors: IRE, BD, ZTX, BU, MJE, BF, 2S, 2N, BC

- In addition

programs (e.g. CAPSXPRT) are available that classify transistors by characteristics.

- The casing or the package of transistors is produced in compliance with standards that almost all manufacturers adopt (such as TO-3, TO-220, TO-92). Some of these standards will be examined readily.



TO-50



Important Parameters: Different for each type of transistor, however, voltage, current, operating frequency, power, shape, B (for BJT models), channel type, and application are generally included. Related

Pictures: The pictures above

Some manufacturers:

Microsemi, Centra-semi, ST, Semelab, M/A-COM, CDIL

Markings Often, the full name of the transistors are imprinted on them but some SMD models have a code include a letter or number or e) is also imprinted on the component.

- Sometimes 2N and 2S are not included in the code, for example:

J281 => is => 2SJ281 & C2120 => is => 2SC2120

- Even the letter "B" is sometimes omitted. For example:

C337 => is => BC337

LEDs (Light-Emitting Diodes) emit light under an applied voltage.

Application:

These components are used when an indicator is required, such as in power indicator lights (in computers, cameras, etc.). By arranging them in desired patterns, LEDs may even be used for decoration.

Color LEDs are used to make large street displays.

Bright LEDs are employed as small projectors (such as in phone camera flashlight). **Main Specifications:**

- Typically, each LED requires a 20 mA current and a voltage of 3~5 V to function.

- Normal LEDs (without holder) are available in circular and flat top models.

- LEDs are generally available in the following models:

Multi-lens

Multi-color

Network or Array

Normal

Panel Indicator

With Frame

With Spacer

- Monochrome and multi-color LEDs are also produced in SMD models.
- LEDs are often available in red, yellow, orange, blue, white, and green colors.
- Single LEDs have two terminals while the multi-color (dual-color) ones have three.
- LEDs can emit various types of lights (from point to extended). In fact, the radiation angle can be changed considering the lens and fabrication technology.
- Single LEDs may come with an opaque or translucent package.
- Circular LEDs (diameter: 3 or 5 mm) are most commonly used.
- In catalogs, translucent LEDs are referred to
- The longer LED pin is always the positive terminal or the anode.
- If the inside of the LED is visible, the wider part (the visible wide metal) is the negative terminal.
- Regarding the color, some LEDs are tagged as HER, which stands for High-Efficiency Red. Important Parameters

Color, opaque or translucent (clear or diffuse), shape, size or diameter, PIV voltage, package color, radiation angle, IF current.

In Array models, the number of LEDs also comes into play.

In models incorporating a frame, the frame material, frame installation method (PCB or Panel mount), the LED position inside the frame (recessed, leveled, or protruded) are also important.

- For the models incorporating a spacer, the length and color of the spacer are also important. Related Pictures:

 LED 2-color

 LED 1-color

  High power LED

       LED SMD 1-color

 LED SMD 2-color

Some manufacturers:

OSRAM, Stanely, Avago

Markings: Often without markings.



LED with frame

These components are generally incorporated into the circuit in a manner that blocks some of the applied sinusoidal waves.

Application:

These components are often utilized as engine speed controllers, light controllers, speed controllers, etc.

Main Specifications:

The most common groups are:

SCR, TRIAC, DIAC

- SCR or thyristor is unidirectional**
- TRIAC enables bi-directional control**
- DIAC is bi-directional but enables a fixed maximum voltage that cannot be controlled. Important Parameters**

Voltage-current, TRIAC, package of SCR.

DIAC voltage

Some manufacturers:

ST, ONSEMI, etc.

Markings

Manufacturer logo (sometimes the name) with the part number.

Allows for programming various behaviors, considering their internal structure, which often comprises silicon chips.

Application:

For integration and miniaturization of electronic boards or when an intelligent board is required. There is an IC for any application, such as:

Application, transformation, attenuation, detection, starting, and many more.

Main Specifications:

Here, only a portion of subjects regarding ICs are covered, therefore, the method of their selection is out of the scope of this book.

- ICs have three major types of terminals:**

THD: Through Hole Device, SMD: Surface Mount Device and socket mount (e.g. PLCC)

- The THD model is often referred to as DIP
- The 4000 series ICs (e.g. 4013, 4001) are members of the CMOS family while the 74 series (e.g. 74125) is from the TTL family.
- CMOS ICs feature an operating voltage of -12~+12 V, while the TTL ICs operate in a range of

0 ~ +5 V.

- There is also a shared IC, known as the TTL- CMOS Compatible IC (e.g. 74 HCT XXXX,

74 HC XXXX, etc.).

- The most famous types of 74 series ICs are:

HC: Hi-speed CMOS

HCT: Hi-speed CMOS TTL compatible

LS: low power Schottky

LV: LOW Voltage

LVC

For example: 74 HC244 or 74 LVC244 or 74 HC4069

- DIP ICs are often made of plastic, ceramic, or metal packages.
- The packages of metal ICs are often similar to the standard transistor packages (e.g. TO-220, TO-39, TO-3, etc.).
- ICs with plastic packages were previously utilized for commercial-grade (temperature range of 0~70 °C) and industrial-grade (-40 ~ +85 °C) applications. However, newer military-grade models have been developed that also incorporate plastic packages.
- Previously, ceramic package ICs were used in industrial and military applications, however, manufacturers are putting them aside for being heavy and fragile.
- All-metal ICs are often used in military or space applications. However, when browsing the catalogs, keep in mind that there are some metal-package models that are designed to operate in commercial-grade temperature ranges.
- When naming ICs, Manufacturers often use prefixes that are specific to them. For example:

MC: On semi , SN: Texas (TI) , ML: Lansdale

- The suffix in the names of ICs indicates the package type and material (CER-DIP, PDIP, SMD, etc.); packaging (waffle, tape, reel, etc.) and whether it is lead-free (ROHS).

- Some manufacturers: have subsidiary brands.

Motorola:

Generally ICs: On semi

Special and obsolete components: Lansdale

Generally RF transistors: M/A - COM

HP => Agilent => Avago

- In contrast, some semiconductor manufacturers are merged together or bought by another company. Siliconix + Telefunken => Vishay

Maxim + Dallas => Maxim-IC

Zetex + Diodes inc. => Diodes

- The most common IC packages are:

P-DIP, Cer-DIP, To-220, To-92, SOIC, TSSOP, PLCC, etc.

Military-grade ICs are often identified with an "883/" suffix.

- Some types of ICs become obsolete and superseded by others with advances in electronics. This must be kept in mind when browsing manufacturers' websites.

- SMD ICs are available in various packages, including:

SOIC, SOP, TSSOP, VQFP, SOT-23, etc.

- The best choice for SMD components is Tape and Reel packaging.

The image of some IC packages is presented in the following:

 **C-DIP (ceramic)**

 **PLCC**

 **LQFP**

 **VQFN**

 **TQFP**

 **SO**

 **D2pack**

 **dip**

 **Soic**

 TSSOP

DIP



SSOP

- TI offers the 74 series ICs in two models with CD and SN prefixes. The main difference between the two types is in their operating temperature ($-40 \sim +85^{\circ}\text{C}$ for the SN type and $-55 \sim +125^{\circ}\text{C}$ for the CD type).

For example:

SN74HC244 & CD74HC244

- The IC package characteristics are presented in the tables on the following pages. Important Parameters

In order to select the right IC, the name of the IC is to be specified after knowing the application. The package (and in some cases, the material) and the manufacturer are the next most important factors. Related

Pictures:

All ICs are similar in appearance; their only differences are in their package and number of pins. A few pictures of ICs were presented on previous pages.

The Most Prominent Manufacturers offering Various Components:

On semi, TI, NSC, Fairchild, ST, Analog Device, Atmel, Intersil, Philips Microchip, Zarlink, Vishay, Toshiba

Markings:

On larger ICs, often, the full name of the component is imprinted. The SMD ICs bear the general IC

a single-letter code is inscribed on very small SMD ICs.

Moreover, the year and week of production is also imprinted on the IC this requires enough space to be available.



5-1 Implications of the Infixes in the 74 Series ICs:

Bipolar

o 74 - The "standard TTL" logic family had no letters between the "74" and the specific part number.

o 74L - Low power (compared to the original TTL logic family), very slow
o 74H - High speed (still produced but generally superseded by the S-series, used in 1970s era computers)

o 74S - Schottky (obsolete)

o 74L - Low power (compared to the original TTL logic family), very slow
o 74LS - Low Power Schottky

o 74AS - Advanced Schottky

o 74ALS Advanced Low Power Schottky

o 74F - Fast (faster than normal Schottky, similar to AS)

CMOS

o 74C - CMOS 4 15 V operation similar to buffered 4000 (4000B) series

o 74HC - High speed CMOS, similar performance to LS, 12 nS

74HCT High speed, compatible logic levels to bipolar parts

o 74AC - Advanced CMOS, performance generally between S and F

o 74AHC - Advanced High-Speed CMOS, three times as fast as HC

o 74ALVC - Low voltage - 1.65 to 3.3 V, Time Propagation Delay (TPD)

2 nS

o 74AUC - Low voltage - 0.8 to 2.7 V, TPD < 1.9 nS@1.8 V

o 74FC - Fast CMOS, performance similar to F

o 74LCX - CMOS with 3 V supply and 5 V tolerant inputs

o 74LVC - Low voltage 1.65 to 3.3 V and 5 V tolerant inputs,

tpd < 5.5 nS@3.3 V, tpd < 9 nS@2.5 V

o 74LVQ - Low voltage - 3.3 V

o 74LVX - Low voltage - 3.3 V with 5 V tolerant inputs

o 74VHC - Very High Speed CMOS - 'S' performance in CMOS technology

and power

BiCMOS

o 74BCT BiCMOS, TTL-compatible input thresholds, used for buffers

o 74ABT Advanced BiCMOS, TTL-compatible input thresholds, faster than

ACT and BCT

Frequency generators are often available in three major groups: 1. Ceramic resonators 2. Crystals 3. Oscillators

Function: As evident from the name, these components are made of ceramic materials and oscillate in combination with a supplementary circuit.

Application: Resonators are commonly used in TVs, watches, phones, etc.

Main Specifications:

Ceramic resonators are made in DIP and SMD models, offering a range of frequencies (300 kHz ~ 20 MHz) with excellent stability.

Important Parameters: Frequency, SMD or DIP, dimensions, accuracy of frequency.



Related Pictures:

Some manufacturers: TDK, AVX

Markings: Often the frequency is imprinted on the package.

Function: Crystals are often integrated into frequency generator circuits. **Application:** Due to the wide range of frequencies that they provide, crystals are applied in many circuits, such as in watches, phones, controllers, communication circuits, and wherever a reference frequency is required.

Main Specifications:

- Various crystals are available, from low-frequency ones (32.768 kHz) that are incorporated into watches to those providing oscillation frequencies in the order of hundreds of MHz: Crystal cases are associated with well-known models, including AT-51, UM-5, HC49, etc.

- Crystals are generally associated with an accuracy of 20 ppm



. To further increase the accuracy, crystals of much larger dimensions is required which are drastically more expensive; hence, oscillators are used for higher accuracy.

Important considerations about crystals

Important considerations about crystals When it is said that the accuracy of a crystal is 20 ppm, it indicates the variations of the frequency in the rated range of operating temperature.

frequency in the rated range of operating temperature.

The production tolerance of crystals is reported in the catalog by the manufacturer as Adj. frequency and is measured at 25 °C.

frequency and is measured at 25 °C.

Furthermore, the tolerance is increased with each passing year. This is specified in the manufacturer catalog as Aging.

manufacturer catalog as Aging.

The tolerance of crystals is often 20 ppm or more at -40 ~ 85 °C. More accurate crystals, featuring a tolerance of around 5 ppm, are available at lower temperatures (e.g. 0 ~ 70 °C).

featuring a tolerance of around 5 ppm, are available at lower temperatures (e.g. 0 ~ 70 °C).

The Load Capacitance must be also taken into account when choosing a crystal, which is a capacitor parallel to the crystal. However, some manufacturers: do not provide any option in this regard and the parameter is rated as fixed in their catalogs.

regard and the parameter is rated as fixed in their catalogs.

TCXO must be used for smaller tolerance values.

Parameters: Frequency, dimensions or CASE, accuracy, operating temperature. Related Pictures:

 **SMD**

 **HC-49 package (Dip and SMD)**



AT-51 package (Dip and SMD)

Some manufacturers:

NDK, PDI, RAKON, QUARTZCOM, RALTRON

Markings: Often, the frequency and the manufacturer logo are imprinted on the package.

Function: These components comprise crystals and supplementary circuits for enhancing the accuracy. Oscillators are special-purpose components and are classified in the following groups: 1. ECL crystal clock

2. OCXO (Oven Controlled Xtal OSC)

3. SPXO (Simple Package Xtal OSC.)

4. TCVCXO (temperature Compensated Voltage Controlled Xtal Osc.)

5. TCXO (Temperature Compensated Xtal Osc.)

6. VCXO (Voltage Controlled Xtal Oscillator)

Simple Package Xtal Oscillators often feature frequencies in the range of 38 kHz ~ 220 MHz. Temperature Compensated Xtal Oscillators offer frequencies in the range of 700 kHz ~ 200 MHz. These components are the second most common frequency generator, after crystals.

Oscillators are very accurate (0.1 ~ 5 ppm), some models even incorporate an adjustment screw for obtaining the desired frequency.

DIP TCXO

Voltage Controlled Xtal Oscillators often provide a frequency range between 2 and 700 MHz.



SMD VCTCXO (VTXO)

Oven Controlled Xtal Oscillators often provide a frequency range between 5 and 70 MHz. These components are very precise and are often used in precision measuring devices that require a reference frequency with practically zero tolerance.

CLOCK OSC. This type of oscillator features a lower frequency compared to the TCXO.

- The accuracy of frequency in oscillators is only valid in the range of operating temperature. Manufacturers: NDK, PDI, RAKON, QUARTZCOM, RALTRON Markings : Component frequency, oscillator model or series, manufacturer logo.



SMD TCXO AND CLOCK OSC

1. Wire

2. 2-CORE 8-SHAPE WIRE

3. Cable 4. Optical fiber

Considering fact that cables are composed of multiple wires, we examine wires first.

Function: Wires are used to conduct electricity from one point to another.

Application: In all devices where a connection is to be made to allow the transmission of current or data.

Main Specifications:

- Wires are always single-insulated**
- The wire core is either solid or stranded (composed of a large number of intertwined solid wires)**
- The following are the most common wires:**
 - 1. Copper solid core non-insulated**
 - 2. Enameled solid core without insulating plastic coating**
 - 3. Gold/Silver-plated wire solid core non-insulated**
 - 4. Mono-color (PVC-coated)**
 - 5. Multi-color (PVC-coated)**
 - 6. Silicone wire (silicon-coated)**
 - 7. Silver solid core**
 - 8. Teflon (Teflon-coated)**
 - 9. Military-grade wire**
 - 10. Thread**
 - 11. Optical Fiber**
- Wires in groups 1, 2, 3, and 7 are only available with solid cores while the rest are manufactured in both solid-core and stranded types.**
- Enameled wires are generally used for making coils and transformers.**



- Typical PVC-coated wires are used for general applications in the household, circuits, and industries. This coating can withstand commercial-grade temperature ranges.**
- Teflon- and silicon-coated wires are fireproof and are generally employed in industrial and military applications**



WIRE

- Teflon wires are very stiff and allow deformation similar to solid-core wires.
 - Silicone jackets are very soft.
 - Military-grade wires have steel strands weaved into the copper strands and are coated with a hard material. This type of wire is often used for military purposes where troops or vehicles pass and the wire is placed on the ground.
 - Coated wires have two types of cores: tin-plated and non-plated cores.
 - The tin-plated wire features easy soldering.
 - The wires may have tin-, nickel-, or silver-plated cores. Tin offers good solder ability, while nickel strengthens the wire and silver has excellent conductivity.
 - The allowable current in the wire depends on the diameter of the wire. The corresponding AWG (American Wire Gauge) standard table is presented on pages 64-65.
 - Moreover, SWG stands for Stranded Wire Gauge.
 - Sometimes, numbers such as 19/0.15 can be found for wires in catalogs, implying 19 strands of 0.15 wires. $15 = 0.15\text{mm}$
- It is evident that there are multiple definitions for one AWG, for example:
- 26 (1) 26 (7/34) 26 (19/38)
- These numbers imply:
- 26 (1) : AWG26 wire, single-strand
- 26 (7/34): AWG26, seven intertwined AWG34 strands
- 26 (19/38): AWG26, nineteen intertwined AWG38 strands
- Multi-color wires have a main color and one to three color bands on the jacket.
 - Some wires have very thick insulations (jackets) to increase the isolation voltage of the wire.
 - AWG50 shows the thinnest wire while AWG0000 represents the thickest one.
 - Braided wires are coated with cotton or silk and are generally used to wind inductors in matching circuits.
 - In the following, first the melting point and operating temperature of the wires, then the AWG standards, and finally, a comparison between

the wire jacket materials are presented. Notice:

1. All four tables can be used for both free and cable wires.

Note that, in the first table, the operating temperature of the wire does not indicate the temperature at which the wire is melted and damaged. For example, PTFE is associated with an operating temperature of 260 °C while its melting point is 400 °C.

Operating temperatures and the melting points of the insulation

Material PTFE FEP PFA ETFE SILICON PVC

Operating temperature (°C) 260 205 260 155 1300 70 Melting Point (°C)
327 260 305 270 1414 80

Some manufacturers: Alpha, Soltech, Helektra



Operating Resistance Material temperature to
(°C) Weather Gasoline and
diesel
fuel

Oil Flammability

Polyvinylchloride PVC "-30~+70" Average Average Good

Polyvinylchloride PVC "-20~+90" Average_{heat resistant}

High-Pressure HDPE "-50~+70" Good_{Polyethylene}

Low-Pressure LDPE "-50~+100" Average_{Polyethylene}

Average

Good Self
extinguishing

Self
extinguishing

Poor Average Flammable

Poor Average Flammable

Polyurethane PUR "-40~+100" Excellent Good

**Good Self
extinguishing**

Polyamide PA "-40~+80" Good Average Good Flammable

Polybutylene PBTP "-60~+110" Good_{terephthalate}

Good Good Flammable

**Polytetrafluorethylene PTFE "-190~+260" Excellent Excellent Excellent
Inflammable**

Tetrafluoroethylene

Hexafluoropropylene FEP "-100~+200" Excellent copolymer

Ethylene ETFE "-100~+150" Excellent_{tetrafluoroethylene}

Perfluoralkoxy PFA "-190~+260" Excellent_{polymer}

Excellent Excellent Inflammable

Excellent Excellent Inflammable

Excellent Good Inflammable

Chloroprene rubber CR "-40~+100" Excellent Poor Good

Silicone rubber SI "-60~+180" Excellent Poor

**Average Self
extinguishing**

Lower

Flammability

Ethylene vinyl acetate EVA "-30~+125" Good Poor Poor Flammable

Ethylene propylene EPM/"-30~+120" Good_{rubber EPDM}

Thermoplastic TPE-O "-40~+120" Excellent_{polyolefin elastomer}

Thermoplastic TPE-E "-70~+125" Excellent_{polyester elastomer}

Styrene triple block TPE-S "-75~+105" Average_{copolymer}

Poor Poor Flammable

Average Average Flammable

Good Excellent Flammable

Good Poor Flammable

7-2 2-CORE 8-SHAPE WIRE

Application:

Often employed as stereo wire, Audio-Video, or household electrical wire. Main Specifications:

- These wires are two insulated wires that are stuck together.
- This wire is similar to single-strand wires in all parameters.
- This type of wire is often available with a stranded core.

Important Parameters:

Copper cross-section, insulation color, allowable voltage

Related Pictures:

 **2-CORE 8-SHAPE WIRE**

 **Stereo wire**



Main 8-shape wire

Some manufacturers:

All wire and cable manufacturers

Markings:

Often the AWG code and the cross-section are imprinted on the wire.

7-3 Cable

The following are the most common cables in electronics:

- 1. Coaxial**
- 2. Coiled**
- 3. Data (FCC 68)**
- 4. Normal (communication)**
- 5. Ribbon (monochrome, multi-color, FFC)**
- 6. Power**
- 7. With Coaxial Wires**
- 8. With Multi-Pair Wires**
- 9. With Shielded Wires**

Application: Coaxial cables are employed for high-frequency data transmission (UHF, VHF, HF, etc.).

Main Specifications:

- Coaxial cables are available in semi-rigid and flexible types.

- Semi-rigid cables are composed of a solid core, plastic jacket, and a copper shield on the exterior. This type of cable can be easily formed into the desired shape.
- The flexible type does not have a particular form and is soft.
- The exterior of the semi-rigid coaxial cable is conductive.
- Flexible coaxial cables are available in solid- and stranded-core types.
- The flexible cables are made in internationally-recognized standard sizes, with the most common being RGXXX, LMRXXX, XC-XV series. The numbers indicate the cable material, diameter, insulation type, core, and jacket material and color: RG58/U, LMR500, 3C-2V
- Some types of flexible cables (e.g. RG214) contain two shields. RG214
- Flexible cables always have braided copper shields.
- When long cables are needed, low-loss cables such as RG213, or even better, LMR-500 must be used.
- Flexible cables are available with normal and fireproof jackets. The fireproof jacket is produced in brown, white, pink, yellow, blue, and bronze colors while the normal type is often black.
- Coaxial cables offer a range of impedances, co
- Semi-rigid cables are often recognized with the standard code UT-XX (e.g. UT-25).
- RGXXX cables are the most common types of RF cables.

Important Parameters: Standard code, type of cable (semi-rigid, flexible), impedance, cable diameter, jacket color, number of shields, type of jacket (as mentioned earlier, the standard code indicates all the other parameters).

Related Pictures:

 Semi-Rigid

 Flexible Flexible:



Twinax :



Some manufacturers:

Flexible: Times, Alpha, Belden, Harbour

Semi Rigid: Times

Markings: Generally, only the standard code is imprinted on the insulation. However, almost nothing is inscribed on semi-rigid cables.

Main Specifications:

These cables often have FCC connectors attached to them and are mainly used to connect to the Internet, intranets, and telephone networks. Hence, being known as network cables.

- These cables are available in 4, 6, and 8 strand types.
 - Data cables are often produced with a solid core; however, stranded core models are available too
- Important Parameters** Number of strands, jacket color, type of core, AWG code
- Related Pictures:**



Some manufacturers: Belden

Markings: part number and name, number of strands.

Main Specifications:

- These cables are employed in many applications including, communications and networks.
 - This type of cable is an assembly of one or more normal or fireproof wires of different colors.
 - The conductors running inside the cable can be normal or fireproof. In general, all other wires and cables (except for ribbon and flat cables) can be incorporated into these cables.
 - Often braided or aluminum foil shields are used in these cables.
 - Shielded cables may incorporate aluminum foil or braided shields, or even both where the braided shield is placed on top of the aluminum shield.
 - Cables may feature a separate ground wire too.
 - In some cases, a sturdy wire or string is integrated into the cable to help cut the jacket.
 - In order to cover all applications, cables are available with a variety of jackets made of different materials, from typical PVC to heat- or frost-resistant, and corrosion-resistant materials.
- Important Parameters:** The number of conductor strands, core type, wire jacket material, AWG code of the wires, number of shields, color, cable diameter, jacket material, jacket color.
- Related Pictures:**

 multicolor braid shield

 2-shield(braid+foil)

 Foil shielded



Some manufacturers:

Markings: Sometimes, the part number, sometimes the number and diameter of the incorporated conductor strands or their AWG code.

Without shield Alpha, Soltech,

These cables are available in FFC (Flat Flexible Cables) and normal ribbon types. a) Normal Ribbon Cables

Main Specifications:

- Being composed of 4 to 64 conductor strands running in parallel, ribbon cables are shaped like tapes.
 - Ribbon cables can be classified into monochrome (often gray) and multi-color (rainbow) cables. The multi-color type features a maximum of ten colors and the colors are repeated if the cable incorporates more than ten conductors.
 - The wires used in ribbon cables are often of the AWG28 type and are spaced 1.27 mm apart. However, manufacturers may use thicker wires that are placed further or closer to one another.
 - The only type of connector used for ribbon cables is the Insulation-Displacement Connector (IDC).
 - These cables are also available in Al-foil shielded types comprising jackets.
 - In monochrome cables, the first wire on one side is marked by a color stripe to serve as an indicator.
 - Some manufacturers: produce fully-fireproof ribbon cables for military applications.
- Important Parameters:** The number of conductor strands, the number of colors, the AWG code of the wires, wire spacing, jacket material, shielding.

Related Pictures:



Flat Ribbon cable for IDC, Color and Gray

Some manufacturers:

Normal : Alpha, Tyco, Molex Fireproof: Tyco (Madison Cable)

Markings: Often without markings.

b) FFC Ribbon Teflon Flat Flexible

Main Specifications:

- These cables are composed of copper conductors that may be tin-plated, running in parallel on a Teflon sheet.
- FFC ribbon cables often incorporate 2-60 conductor strands.
- Special connectors, known as the FFC or FPC, are used for this type of cable.
- The covering is often white or gray.
- These cables are often short (in order of centimeters).
- The center-to-center distance between the conductors is between 0.3 to 2.54 mm (most commonly

1 mm).

- The two ends of the cable, that is to be placed in the connector, are either stripped or the cable is coated with an adhesive tape on one side. The copper connectors on the rest of the cable are fully covered.
- Three types of cable ends are available: 1. without supporting tape 2. Coated on the connecting face (both on the same side) 3. Coated on the opposite side
- The copper conductors are often 0.1 ~ 0.3 mm wide.

Important Parameters: The number of conductor strands, conductor spacing, the stripped length, tape length, attachment of tape to the ends of the cable, copper conductor width.



Some manufacturers: Thomas & Betts, AVA, etc.

Markings Often the part number and name.

Application: Used in handsets and corded phones.

Main Specifications:

- For transmission of data from the device to the handset.
- The coiled length of the cable is typically between 1.3 to 1.5 m.

- Flexible wires of any type can be incorporated into this cable.
 - Coiled cables are produced in both shielded and unshielded types.
 - Shielded cables may incorporate aluminum foil or braided shields, or even both where the braided shield is placed on top of the aluminum shield.
 - Typical PVC or fireproof (silicon, etc.) wires may be integrated into the cable.
 - The cable covering may be fireproof or normal.
- Important Parameters:** The number of conductor strands, the AWG code of the wires and their jacket material, cable material, the overall length and the length of the coiled part. **Related Pictures:**

Some manufacturers: Soltech, Philatron, etc.

Markings Manufacturer and part number, sometimes, the number and the AWG code of the integrated wires.

Main Specifications:

- These cables often comprise two or three conductor strands (two phase strands and one ground) and are not generally shielded.
 - Often a connector is attached to one or both of their ends. A plug is attached to one end, while the other end is either free or attached to an IEC (male or female) equipment connector.
 - Connectors have both straight and right-angle modes.
 - These cables are often produced in 1 to 3m-long pieces.
 - They are generally black, white, or gray.
 - The maximum allowable current in these cables varies from 2~16 A.
- Important Parameters:** Cable length, the type of connector on each end of the cable, cable color, rated current.



Power cord

Some manufacturers: Alpha, BELDEN, AVA, etc.

Markings Rated current and voltage, safety standards (in compliance with the international verification symbols).

- These cables incorporate a number of typical wires similar to normal cables but have a few strands of RF cables too. These cables are custom-made as ordered by customers. When ordering, the corresponding RGXXX code of the RF cable must be also specified.

Some manufacturers: Soltech,

- Similar to typical cables, the only difference is that the solid wires are twisted in pairs. This type of cable is mainly used in telephone wiring.

 With multi-pair wires, braid shield

Lapp kable, Belden, and Alpha can be mentioned as the best-known manufacturers of this cable.

- Similar to typical cables, a few of the conductor strands are shielded to protect them against noise. These cables are also custom-made.



with shielded wires (NO. 2 is shielded wires)

Some manufacturers: Soltech,

7-4 Optical Fiber

Function:

Optical fibers transmit data via photons.

Application:

When current is of no significance in the transmission of data, and it is only important to transmit the data, such as the Internet network.

Main Specifications:

- Optical fibers are mainly available in glass and plastic types.
- Glass optical fiber features small loss and is used in long-distance applications, however, it is associated with a larger time delay and breaks when bent.
- On the other hand, the plastic type offers a more limited range due to its high loss. However, it features a small time delay and is flexible and for short distance.
- Optical fibers are generally produced in single-mode and multi-mode types.
- Single-mode optical fibers transmit only one wave.
- The multi-mode optical fiber carries multiple waves but the

transmission (TX) and reception (RX) routes are different.

- The connectors on the two ends of the fiber are, in fact, RX or TX circuits.

Important Parameters:

Copper and enameled wires: Wire diameter

Gold- or silver-plated wires Wire diameter, jacket thickness

Normal, silicon, and Teflon wires: The AWG code, jacket color(s), core type, plating.

Silver wires Wire diameter, silver content

Military-grade wires wire diameter + related military specifications

Some manufacturers:

Enameled wire: A common product of many manufacturers

Normal, Teflon, and silicone wire: Alpha, Helektro, Belden

Gold- and Silver-plated copper wire Scientific wires

Markings:

Often no markings due to the small thickness of wires. However, the manufacturer name, wire

thickness, or the AWG code may be imprinted on thicker wires.

Function:

Batteries provide a constant voltage (DC) through their internal electrochemical reactions.

Application:

In toys, cars, watches, emergency power systems, military equipment, etc.

Main Specifications:

The major types of batteries by structure:

1. Dischargeable

2. Rechargeable

Standard battery sizes:

PP3 (9-Volt)

AA , 2/3 AA , 4/5 AA , 1/2, (AA) W(mm) D(mm) L(mm) AAA , 1/4 AAA , 1/3AAA ,
2/3AAA ,

5/3 AAA , 5/4 AAA_{10.5 44.5} AAAA , 2/3 A , 4/5 A

C 14.5 50.5 AA D

26.2 50 C

34.2 61.5 D

26.5 17.5 48.5 PP3 2016, 2025, 1620, 2032, 2430, 2450, 2477: Button, or watch cell

Notice: Some batteries are made in non-standard sizes.

Common Voltages: 1.5V, 1.2V, 2.4V, 3V, 3.6V, 3.7V, 6v, 9V, 12V, 24V

Types of batteries by composing materials (fabrication technology):

Standard (Zinc chloride)

Alkaline

Lithium (Li-ion, Li- FeS₂, Li-MnO₂, Li-SOCl₂, Polymer, Li-Thionyl Chloride) Silver Oxide Nickel-based batteries: Nickel-Cadmium (Ni-Cd), Nickel Metal Hydride (Ni-MH)

Sealed Lead-Acid (car battery)

Solar Cells

Calcium Gel

- The following batteries are dischargeable:

Standard, Alkaline, Alkaline MnO₂, Alkaline Zinc MnO₂, Lead acid, Li-SOCl₂,

Li-FeS₂(Li-Iron disulfide), Li-Thionyl chloride, MnO₂, Nickel Zinc, Silver Oxide, Zinc air, Zinc Carbon, Zinc Chloride, Zinc MnO₂

- The following batteries are rechargeable:

Ni-Cd, Ni-MH, Li-polymer, Li-ion, Calcium gel, Sealed lead acid, Li-Vanadium

and car battery

- Solar cells have a non-chemical structure and are made of photo-sensitive silicon wafers. In these cells, voltage is generated by the collision of photons with the silicon wafers.

- Sealed Lead-Acid batteries are mainly used in emergency power systems (e.g. UPS).

- Calcium Gel batteries are used in cars and have a longer service life compared to lead-acid batteries. Silver oxide batteries are commonly used in calculators, watches, and photography equipment due to their

excellent stable charging time.

- Rechargeable batteries have a certain lifetime. When stored, Lithium batteries must be charged once every six months, and the Cadmium batteries once every three months to prevent oxidation and sulfating.

Operating temperature

- Li-MnO₂ batteries: -40 ~ 60 °C

- Li-SOCl₂, Li-Thionyl Chloride batteries -55 ~ +85 °C

- Li-polymer, Sealed Acid batteries -20 ~ +60 °C

- Other batteries operate in a temperature range of 0 ~ 40 °C or -10 ~ 50 °C that is specified in their catalog.

- Batteries must be stored under controlled conditions (temperature, humidity, etc.) according to the catalog because of their fast depreciation under unfavorable conditions. Moreover, batteries are fire hazards and must be stored accordingly.

- Recharging lithium batteries (e.g. cell phone batteries) before being fully depleted extends their life. Important Parameters

**Voltage, size, rated current, operating temperature.
Related Pictures:**

 **Alkaline Zn-MnO₂**

 **CR2032**

CR2025

 **Nickel Zinc**

 **LI-MNO₂ size C**

   **CR2016**

  **Silver Oxide**

Solar panel

Alkaline MnO₂

Some manufacturers:

VARTA, Saft, Maxell, Great power, Able, Rocket, Ultralife

Markings

Often, the rated voltage and current are imprinted on the battery; however, the current capacity is rarely indicated on standard

disposable batteries.

The major groups of audio components can be summarized as follows:

9.1 Buzzer or alarm (with internal driver circuit)

9-2 Microphone

9.3 Piezoelectric ringer

9.4 Sounder

9.5 Speaker

9.6 Transducer (with external driver circuit)

9-1 Buzzer or alarm

Function: Generates a constant frequency (generally 2~4 kHz) by receiving a DC voltage. **Application:** Used for alarming purposes in different systems such as computers, open-door signals, watches, gas and smoke alarms, etc.

Main Specifications:

1- Available in DIP and SMD models.

2- Some models are fabricated for military applications (-40 °C and waterproof).

3- These components are produced for a wide range of DC voltages (often from 2-3 V up to 15, 25, or even 35 V).

Important Parameters: Operating voltage, operating frequency, output sound volume, dimensions, pitch, operating temperature.

Related Pictures: SMD buzzer

Some manufacturers: Kingstate, OBO

Markings part number and name, operating voltage.

9-2 Microphone

Function: In general, microphones are capacitor (condenser), carbon, or dynamic. The capacitor type comprises two plates, one of which is fixed and the other moves by sound. The change in the distance between the two plates changes their capacitance.

In carbon microphones, sound pressure changes the impedance of carbon layers.

In dynamic microphones, an output voltage is generated by the movement of the core of a coil.

Application: At the input of all systems requiring to receive sound and to transform it into voltage (such as amplifiers, telephones, etc.).

Main Specifications:

Microphones are generally divided into the following groups:

- 1. Omni directional**
- 2. Unidirectional**
- 3. Noise-canceling**

Omni directional microphones may be sealed during fabrication, however, sealing the unidirectional microphones is not possible given the holes at the back of the microphone for leading the sound in one direction.

Noise-canceling microphones are designed for speaking closely into them to cancel the ambient noise. Important Parameters: Sound direction, input sensitivity, operating frequency, dimensions. Related Pictures:

Some manufacturers: Panasonic, Citizen, Vec, Primo, JLI

Markings: Often without markings.

9-3 Piezoelectric Ringer

Function: This component generates a ring at constant frequency when a fixed AC voltage is applied to the input.

Application: These components are often used in telephones; however, advances in semiconductors are limiting their application.

Important Parameters: Sound pressure level, allowable input voltage, operating temperature and dimensions.

Related Pictures:

Some manufacturers: Murata, OBO

Markings: Often either without markings or get printed

Function: This component generates one or multiple sounds at a constant frequency under an applied voltage.

Application: The most common type of this component is the car alarm siren.

Main Specifications:

- Sirens fall into this category

Important Parameters: Operating voltage, number of output tones,

output frequencies, dimensions, and installation location.

Related Pictures:



Some manufacturers: FDK, Klaxon

Markings:

Function: In this component, sounds are generated by the movement of a magnetic core, and the membrane it is attached to, as a result of an applied voltage.

Application: In all devices, household appliances, and industrial equipment that are required to emit sounds.

Main Specifications:

- **Models:** PCB mount, free mount, Panel mount
- **Shapes:** Round, square, oval, and rectangular.
- **Types:** Paper cone speakers, plastic or titanium membrane speakers, PEN membrane waterproof speakers, military-grade PEI membrane speakers.
- **Size:** 10 mm and above.
- Recently, shielded speakers have also been produced whose electromagnetic fields have been eliminated.
- **Common impedance for speakers are:** 4,6,8,16,20,25,32,40,150,300R
- Some models, such as piezoelectric speakers, are available that produce weak frequencies and have few applications, such as in some notebooks.
- In the waterproof models, a rubber ring is placed around the membrane which is itself impermeable to water.
- Some speakers are fabricated for certain frequencies. For example, Tweeters are specific to high frequencies, while Woofers are low-frequency speakers.

Important Parameters: Dimensions (diameter, length and width), thickness, impedance, operating frequency, output power, operating temperature, resistance to water, output sound pressure. **Related Pictures:**

Piezo

 **General speakers:**

  **Some manufacturers: Tweeter**

 **Woofers**



Veco, ISL, Holmco, Kingstate

Markings: Often the power and impedance are imprinted on the back of the speaker while, sometimes, the part number and manufacturer

Function: This component generates sound when a fixed frequency is applied to it. **Application:** In toys, household appliances, communication equipment, etc. **Important Parameters:** Sound pressure, allowable input voltage, capacitance, dimensions. **Related Pictures:**



Some manufacturers: OBO, Kingstate

Markings:

The human ear is capable of hearing sounds from 20 Hz up to 20 kHz. The upper limit varies with age as younger people may hear frequencies up to 20 kHz while the elderly are not capable of hearing above 6 kHz.

The dynamic range of sounds is measured in dB which is 10 times the logarithm of the loudest sound divided by the weakest sound.

$1\text{dB} = 10 \log (P_1 / P_2)$ & $1\text{dB} = 20 \log (V_1 / V_2)$

The dynamic limit may vary from 30 to 100 dB in a musical piece.

Moreover, some other units associated with dB are:

dBm: (based on $0\text{dB} = 1\text{mw}$)

dBu: (based on $0\text{dB} = 0.775\text{Vrms}$)

dBV: (based on $0\text{dB} = 1\text{Vrms}$)

dBW: (based on $1\text{w} = 0\text{dB}$)

Examples Pressure dB

Airplane 20pa General music
Inside a train 2pa Crowded street
Workshop 0.2pa Crowded office
Normal conversation 0.02pa Quite office
Village house 0.2upa Quite conversation
Whisper 2upa Quite outskirts at night
Soundproof room 20upa 120

**Threshold of
discomfort**

110

100

90

80

70

60

50

40

30

20

10

0 Threshold of hearing

Classification of Sounds

Caps are used as covers, holders, or dust caps.

In this section, only caps and covers with electronic applications are discussed.

- 1. D-connector cap**
- 2. Fuse-holder cap**
- 3. Multi-pole connector cap**
- 4. RF connector cap**
- 5. Switch lever cap**

Important Parameters: The number of connector pins, color



Related Pictures:

Manufacturers: Assmann

Important Parameters : Cap shape (screw, push-on), fuse size (diameter), cap length

Related Pictures:
Manufacturers: Schurter

Important Parameters Connector name, cap type (plug or jacket), shell size, screw attachment ring, diameter of the hole below the screw

Related Pictures:

 **Cap for Jack**



Cap for Plug

Manufacturers: Amphenol, FCI, Soltech, ITT Cannon

Important Parameters: Connector name (BNC, SMB, etc.), connector type (Male, Female), having an attachment chain or string, color, method of connection to the connector (open: without connecting the connector core to the casing, short: connecting the connector core to the casing).

Related Pictures:

Cap for N

 **CAP FOR SMA**



Manufacturer: Telegartner, Rosenberger, Radiall, S Conn

Important Parameters: In order to select the right type of cap, the type of the switch and its manufacturer must be considered. Typically, the suitable cap is provided by the manufacturer of the switch.

Related Pictures:

 **plastic cap for toggle sw.**

 **waterproof sealing cap for pushbutton sw.**



sealing cap for toggle sw.

Manufacturers: Knitter sw. Apem

Markings: Sometimes the part number and its name are imprinted on the cap, but they are generally without any markings.

10-2 Covers

1. D-type cover
2. FCC-68 modular cover
3. Push-on insulation cover

Important Parameters: The number of related connector pins, color, body material (metal or plastic).

Related Pictures:



Some manufacturers: Assmann, AVA

Important Parameters The number of connector pins, color.

Related Pictures:



Manufacturers: Assmann

Related TAB size, color



Some manufacturers: AVA, VOGT AG, AKE

11 Connectors

Connectors are the largest and most diverse group of electronic components with many manufacturers. Many connectors are not in compliance with any particular standard and are only produced to meet specific customer demands.

General Aspects of Connectors:

- Most connectors are available in PCB mount, Panel mount, cable mount, straight and right-angle models with DIP or SMD pins. Pictures are presented for each group in their respective sections.
- Connector pins can be tin- (tin and lead) or gold-plated. Gold or gold-plated connectors can be connected to and detached from the opposite contact up to ten times more than those with tin pins.
- Gold-plated pins are available from around (gold-flash) to .
- Panel mount and cable mount connectors often have sealed models

too.

- Metal connectors are often used in industrial or military applications.
- Some cable mount or panel mount connectors feature solderable or crimp pins for wires to be attached. The crimp pins require a special pressing device.
- Sometimes, manufacturers install an EMI filter on each pin in the connector.
- Often different colors in connectors serve to diversify them and do not have a particular significance; however, military-grade connectors are often olive-green.
- The maximum allowable current and voltage in connectors are generally small. For high-voltage and high-current applications, special models are to be employed that will be discussed.
- Connectors are often used in pairs of male and female (the pin is male and the hole is female).
- Jack, in connectors, is the solid tubular side, while Plug is the tubular side that encompasses the jack. This means that jacks are always placed inside plugs; meanwhile, both jacks and plugs may be either male or female.

Connectors can be classified into nine major groups:

1. Audio and video
2. Component socket
3. Contacts and pins (solderable)
4. IDC (for ribbon cables)
5. Mains power and terminals connectors
6. Multipole
7. PCB Interconnect & Data
8. RF & Microwave
9. Test & Crimp
10. Optical fiber

- Although this classification indicates the application of the groups, it will be readily addressed in more detail.

Three major types of audio connectors are available:

Audio Style, DIN Style, Phono

However, there is a fourth type, known as the Audio Multipole

Connector, which will be addressed along with multipole connectors for its similarity to that connector class.

There are other subsets of audio connectors, such as the XLR connectors, that are less common.

Main Specifications:

- In general, audio connectors have a jack and socket structure with the jack always being male and the socket always female.
 - The jack type is always cable mount and is made in both straight and right-angle configurations.
 - Audio connectors are available in Mono (2-pole) and Stereo (3-pole) types and are mainly used to connect microphones to amplifiers.
 - These connectors are made with both plastic and metal package.
 - The socket may be cable mount, panel mount or PCB mount.
 - The diameter of the jack rod is a distinguishing factor and is commonly 2.5, 3.5, and 6.35 mm.
- Important Parameters: Casing, number of poles, casing material and color, jack diameter, installation method, full length.**

Related Pictures:



Some manufacturers: Cliff, Neutrik, Schurter

Markings Without markings

Application: This connector is most commonly used for connecting computer mouse and keyboard. Main Specifications:

- Generally similar to multipole connectors in appearance.
- By standard, this connector may have 3, 4, 5 (180°), 5 (240°), 5 (Domino), 6, 7, or even 8 pins.
- Miniature DIN connectors have 3, 4, 6, 8, or 9 pins.
- The male DIN connectors are cable mount plugs while the female type may be a cable mount, panel mount, or PCB mount socket.
- Some models also have an integrated lock.
- The cable mount or PCB mount is also available in right-angle models.

Important Parameters: The number of pins, gender (male or female), installation method, installation angle.

Related Pictures:

 **MINI-DIN unshielded Mini-DIN shielded**

 **Mini-DIN Dual**

 **Mini-DIN short**



Mini-DIN cable mount

Some manufacturers: Deltron, Hirschmann

Markings: Without markings

Application: Phono connectors are very common and are typically used as connectors for Audio-Video cables.

Main Specifications:

- These connectors are available in Plug (male) and Socket (female) types.
- Commercial-grade and professional (often with metal casing) phono connectors are available.
- Generally, these connectors can be found in a variety of colors (yellow, black, white, red, blue) or with color bands to be easily distinguished.
- The plug phono connector is always cable mount. The socket is often of the PCB mount or Panel mount type.
- There are also adapter phono connectors that have two or three lines.

Important Parameters: Type, installation method, color.

Related Pictures:



Some manufacturers:

Deltron, Neutrik

Markings

Often without markings.

Function: These are plastic components that may integrate pins and facilitate the installation, secure the components, or help insert them or take them out.

Application: These components are used in all electronic circuits, especially in test circuits. The major types of component sockets are:

Normal

IC Socket

ZIF

Relay Socket

Resistor Socket

Transistor Socket

Main Specifications:

- The most common component sockets that are made in a variety of types (circular, DIL, PLCC, SIL, etc
- IC sockets are made with different numbers of pins and are available for all types of ICs.
- In general, there are four types of IC sockets: Formed pin, SMD, turned-pin, and wire-wrap.
- The socket pins may be tin or gold-plated.
-
- The IC socket is often black.
- ZIF (Zero Insertion Force) IC sockets are used for laboratory and test applications. Placing them on top of an IC and pushing their lever down secures the IC in its place.

Important Parameters: The arrangement of the pins, the number of pins, type of pins, the distance between two lines of pins, pin coating.

Related Pictures:

 PLCC socket

 DIL socket

 Turned pin Formed pin

 Wire-wrap

 FPGA Socket

 IC Socket, DIL and SIL



ZIF sockets

Some manufacturers:

Normal: AMP, Harwin, Augat

ZIF: Aries, 3M

Markings Without markings

Relay sockets are often made for high-current relays. Manufacturers often make the sockets matching their relays.

The socket may integrate an LED lamp or a guard, but sometimes, they are plain and simple. Related Pictures:



Manufacturer: Finder

Markings

Manufacturer descriptions, type of the internal circuit, and sometimes the standards. Resistor sockets prevent the deviation of the connection.

This type of socket is almost discontinued today.

Images:



11-2-4 Transistor Socket

- Circular components that either integrate four holes or are cut from four sides.

- These sockets are made in normal diameters (4, 5, 6, 8, 9 mm) and are available in a variety of colors.

Images:



Manufacturer: Fischer

Function:

A small metal rod that may be male or female.

Application:

They are used inside connectors or independently for installation on board.

Main Specifications:

- Pins are often available in male and female (socket) types.
 - Pins may be PCB mount, solderable or crimp.
 - Pins are made in different lengths for different applications.
 - The diameter of the socket hole or the external diameter of the pin may be up to 6mm.
 - The diameter of the wire (in fact, AWG) is important when working with the solderable or crimp contacts.
 - For the types of pins that are embedded inside a connector, the type of the connector must be known.
 - Pins may be plated with tin, tin and lead, gold, or silver.
-
- Some pins and contacts are intended to be integrated into DW connectors and are known as DMW coaxial or power contacts. These components are either soldered to wires or connected to them by a crimp.

Important Parameters

Gender, installation method, length, plating, pin or socket hole diameter, AWG code, type of connector.

Related Pictures:



PINS Some manufacturers:

Vogt-AG, Assmann Markings : Without markings



Function: Connectors that can be easily attached to ribbon cables.

Application: These connectors are generally for data transmission.

Main Specifications:

The major types of IDC connectors are:

1. IDC (Normal) 2. Discrete IDC-D 3. IDC card edge 4. PCB Transition

Of course, there are other types of IDC connector, but they are limited to few applications, for example:

HE14, IDT, MTA

Main Specifications:

HE14

These connectors are available in two types: Cable mount (female) and PCB mount (male).

- Either type may come with an integrated lock.
- The PCB mount type is available in both straight and right-angle models.
-
- The male normal IDC connectors have normal PCB, wire-wrap, or SMD pins.
- These components are often made in white, black, and gray colors.
- The male IDC that does not integrate a lock is known as the box header.
-

Important Parameters: Gender, installation method, number of pins, locking mechanism, type of the pin, type of the male part (straight or right-angle), pin contact cover, color. **Related Pictures:**

IDC female

 IDC male

 SMD Box

   IDC Box header



Strain Relief

Some manufacturers: TYCO, AVA, Molex, Assmann, 3M, ELCO

Markings: Manufacturer name and sometimes the number of pins.

Main Specifications:

- These connectors are similar to a female IDC from behind while resembling a D-sub from the front.
- These connectors may have 9, 15, 25, or 37 pins.
- The D-type may be either male or female.
- These connectors are available with both metal and plastic casings.
- The connection is either between two cables or panel mount.
- Their IDC part may have an integrated lock.

- These connectors are often connected to an AWG28 ribbon cable.
Important Parameters: Gender, number of pins, locking mechanism, casing material. **Related Pictures:**



IDC-D male and female Manufacturers: Tyco, AVA
Markings: Without markings

Main Specifications:

- These connectors are attached to a ribbon cable on one side and to card connectors on the other.
- Similar to the normal female IDC, these connectors may come with a lock (strain relief).
- The contacts may be tin- or gold-plated with various thicknesses.
- The center-to-center distance between the pins (pitch) at the ribbon-cable side is often 1.27 mm and 2.54 mm at the card side.
- In some models, a flange is also embedded into the connector for mounting on the casing or panel. **Important Parameters:** The number of pins, locking mechanism, plating.

Related Pictures :



Some manufacturers: AVA, Elco
Markings Without markings

11-4-4 PCB Transition

Main Specifications:

- These connectors are attached to a ribbon cable on one side and soldered to the PCB on the other.
- They may have two, three, or even four rows of mounting pins.
- These components are made in various colors but often they are black.
- Their pitch is generally 2 or 2.54 mm.
- The
- The pins may be tin or gold-plated.

- These connectors may come with a locking (strain relief) mechanism.
Important Parameters: The number of pins, locking mechanism, pitch, pin plating, width. **Related Pictures:**



Some manufacturers: AVA, Molex, 3M, Assmann

Markings: Sometimes the manufacturer name and sometimes without markings. These connectors are used for in joints to the mains electricity. No. 2 also works for DC power. Mains power connectors can be classified into the following major groups:

1. Barrier Terminal Block
2. DC Power (AC / DC Adaptor Connector)
3. Mains Plug and IEC inlet
4. Mains Socket and IEC Outlet and Socket.
5. Panel Mount Terminal block
6. PCB Mount Terminal block
6. PCB Mount Terminal block

- These connectors are often mounted on the panel with the wires being distributed below these terminals.

- This block may have 3 to 12 positions.

- Often the input and output are connected in one of the following configurations:

Screw Screw

Screw Tag

Fork Tag

Fork PCB pin

Tag Tag

Strip blade Strip blade

Important Parameters: The number of positions, the connection between the input and the output. **Related Pictures:**

 Screw-tag



Some manufacturers: Cinch

These components are available in the following models: AC/DC adapter Connector, DC car Connection, Power Pole

- These connectors are high currents.
- They have either a plug or a socket casing.

11-5-2-1 AC/DC Adapter Connector

These are adapter connectors and their current rating is up to 5 A. The Jack type is often cable mount while the Plug is PCB mount. The shaft is often 2~2.5mm-thick.

- The wires attached to these connectors may be either coiled or normal.



DC Power

11-5-2-2 DC Car Connector

This type of connector is used for connecting car accessories such as emergency lights, cell phone charger, etc. to the car's electrical system. This connector is always plugged into the cigarette lighter socket and their current rating is up to 10 A.



11-5-2-3 Power Pole

Often used in UPS and their current rating is between 15~320 A based on dimensions. These connectors are mostly used in DC applications; however, they are sometimes employed in AC applications too. These connectors are available in single- and double-pole types.

Images:



Important Parameters:

1st Group: Casing, installation, color, shaft diameter.

2nd Group: Casing, type of attached wire.

3rd Group: The number of positions or poles, maximum allowable current and voltage, color. Some manufacturers:

1st Group: Cliff

2nd Group: Hella, Erich-jaeger

3rd Group: Anderson Power Products

- The third pin in the plugs is the grounding pin
- These plugs are often available in PCB mount, cable mount, and panel mount types.
- The PCB mount plug is often right-angle.
- The cable mount type is often attached to straight or coiled cables and is generally produced in white, black, and gray. A sealed type of such cable mount plugs is also produced from IP44~IP67 (the meaning of this code can be found at the end of the book) for particular industrial applications.
- The cable mount plug is produced in straight and right-angle (the angle between the wire and connector) models.
- The panel mount type is very common and is used in many different devices. It is often available in flange-fixing and snap-fit types.
- Sometimes, panel-mount plugs integrate a protective fuse or a current switch.
- The maximum allowable current is one of the important parameters and is commonly 4~20 A. Important Parameters Installation method, maximum allowable current, color, the angle between the connector and its base, cable length (for the cable mount type), integrated fuse and switch (for the panel-mount type).

Related Pictures:



Power cords



IEC INLET



IEC INLET WITH FUSE

IEC INLET WITH FUSE AND SWITCH

IEC INLET 8-FORM Some manufacturers: Schurter, Bulgin, Volex, Hitachi, Walther

Markings: Rated voltage and current, manufacturer, standards (the international verification logo that can be found at the end of this book).

All characteristics is Similar to 11-5-3



Mains Socket IEC OUTLET

- These terminals are made of plastic (Nylon, Polyamide, or Polyethylene) and are installed on the panel or wall with a screw.
- A wire is attached to their input and a screw is attached to the output, therefore there is always an even number of screws and two screws exist for every position.
- They can generally withstand a current of 6, 10, 16, or 32 A.
- These terminals are often 12-way but can be divided into smaller pieces.
- These terminals are often white, gray, or colorless.
- These terminal blocks are often used for building wiring and lighting purposes. Important Parameters: The number of positions and the rated current.

Related Pictures:



Some manufacturers: Metway, connex-electronics

- These terminals are mounted on PCB. The wire is directed into them and fastened in the terminal by a screw or spring.
- These terminals are available in right-angle and straight body orientations.
- The pitch distance may be 2.5, 5, 7, or 10 mm.
- These terminal blocks are commonly produced in green, blue, black, white, and gray colors.
- There are 2 to 12-way PCB mount terminal blocks but they can be daisy-chained for a higher number of positions. Therefore, the 2 to 3-way models are the most common.
- The rated current for this type of terminal block is 6 to 24 A.
- In some models, the wire is not fastened by a screw but the terminal

itself has a spring holder. Important Parameters: Pitch, number of positions, color, rated color.



Images:

Some manufacturers: Phoenix contact, AMP, IMO

These connectors are mainly available in round and rectangular shapes and have a high maximum allowable current.

This model has a large pitch (3.96, 5, 7.5, 10... Mm) and is used in various high-current applications.

the right choice. A few pictures of this type of connector are presented below:



Some manufacturers:

Or, for a better evaluation, it is recommended to consult Farnell's website

Important Parameters: The number of positions, current, shape, body type, male and female, etc. Markings

Function: These connectors feature high rated currents and are often used to connect two cables or one cable to a device. Moreover, some types of these connectors are used to connect cables to a board.

Application: These connectors are often used in military devices such as radio systems; however, thanks to their low price they have also found many industrial applications.

Main Specifications:

- The cable attached to these connectors is often rounded but the harness can also be placed into them.**
- These connectors may have 1 to 100 pins.**
- Often, they have an olive-green covering, but it may be black or silver too.**
- These connectors generally feature a metal casing.**
- Circular multipole connectors are made in different models and in compliance with various standards.**

For example, MIL-C-5015 which is the primary type of military-grade connectors. Given its large dimensions, the 5051 model was replaced by newer, smaller models that were in compliance the MIL-C-26482 standard.

- There are a few important points to consider about these connectors when choosing from them:

Whether it is male or female, whether it is jack or plug, and the shell size. The shell dimensions are in compliance with the international standards that all manufacturers follow and are similar for all military-grade multipole connectors. Shell sizes are available from 8 to 52 with 8 being the smallest.

- These connectors feature various installation methods based on the application. Some of the installation methods are mentioned in the following:

- 1. Cable mount with clamp**
- 2. Cable mount with crimp**
- 3. Cable mount with backnut**
- 4. Panel mount with square flange**
- 5. Panel mount with panel-jam nut**
- 6. Panel mount with circular flange**
- 7. Panel mount with back shell**
- 8. Panel mount with clamp**
- 9. Panel mount with nut or PCB mount pins**

The images below show the various connection methods for MIL-C-26482 connectors:

Square flange receptacle with straight cable clamp

Square flange receptacle with straight backshell for potting

Square flange receptacle with straight adapter

Square flange receptacle with straight backshell for heatshrink sleeve

Square flange receptacle with removable straight backshell for heat-shrink sleeve



Square flange receptacle with removable straight backshell for screen termination and heat-shrink sleeve

 **Square flange receptacle with straight sealing gland backshell**


Square flange receptacle with straight sealing gland and cable clamp

 **Jam nut receptacle with straight cable clamp**

 **Jam nut receptacle with backnut**
Jam nut receptacle with straight backshell for potting
Jam nut receptacle with straight backshell for heat-shrink sleeve

Square flange receptacle not accepting backshell

Jam nut receptacle not accepting backshell

Cable connecting receptacle with straight clamp

Plug with backnut

Plug with straight cable clamp

Plug with straight backshell for potting

Plug with removable straight backshell for heat-shrink sleeve

Plug with straight sealing gland backshell

Plug with straight sealing gland and cable clamp backshell

Plug with elbow cable clamp backshell

Plug with elbow backshell for potting

Screened plug with removable straight backshell for screen termination and heat-shrink sleeve

Screened plug with lock finger and short backshell for screen termination and heat-shrink sleeve

 **Hermetic connectors**

 **There are four connection methods for round connectors:**

1. Push-Pull: The connectors are attached and detached directly. This method is the quickest.

 **push-pull multipole**

2. Screw: This is the most common connection method in the MIL-C-5015 series.



MIL-C-5015

3. Bayonet: The two connectors are locked in place by half turns. This is the most common connection method in the MIL-C-26482 series.

4. In the connectors complying with the QPL standard, the two pieces are connected directly and fastened by a screw in the middle. These connectors often feature a high current.



Series QPL

- Often in circular connectors, one side has a male pin while the other has a female socket (similar to the groups mentioned above). However, in some circular connectors, the male and female parts have flat pins that come in contact when the two parts are connected. There is also a spring beneath them that pushes them toward each other for a better contact. These connectors are known as audio connectors and the best-known member of this type of connector is the NF series that is manufactured by Schaltbau or Soltech. These connectors are joined by a bayonet connection.



NF series

- Circular connectors with pins and sockets often have a limited number of mating cycles (500 to 1000 times).

In case the connector is required to have a longer life, the NF series are recommended that can be connected and disconnected up to 5000 times.

- Given their metal casings, circular connectors are often associated with a military or industrial operating temperature range.

- The size of pins integrated into the connectors may be different. The size is specified in the catalog

20, and 22. These numbers show the AWG of the wire which is to be attached to the contact and, in fact, represent the rated current of the contact (pin). The following table shows the rated current for each contact size:

Contact Size (wire AWG) Maximum Current (A)

22 5

20 7.5

16 13

12 23

8 46

4 80

0 150

- The arrangement of th

-

Following the arrangements, numbers similar to the example below may be given: 18-21

4-#16

This implies:

1) Shell Size insert arrangement

NO. of Contacts Contact Size

above for MIL-C-5015 connectors Shell=18, the number of pins is the same as insert arrangement, however, 18-10 in the same group represents a four-pin connector as follows:

18-10

4-#12

- MIL-C-5015 series include connectors incorporating pins with different sizes in one arrangement

which is less common in other series.

- Military-grade circular multipole connectors have a military standard number that is recognized by all manufacturers. Manufacturers either use the standard number or, in case of using their own part numbers, the products match those of the standard number. For example, in the MIL-C-5015 standard, MS3108 represents right-angle cable mount, and MS3101 represents panel mount with panel-jam nut, or in the MIL-C-26482 standard, MS3110, 3112, 3119, and 3114 represents panel mount and MS3116 represents cable mount.

Sungjin adopts exactly the same codes, while Amphenol has both these codes and its own part

-C-26482 standard.

- There is another standard which is still followed by manufacturers. In this standard, the connector part numbers have the form: "U - three-digit number". For example:

U 316/U: Fourteen-pin connectors with Shell=12 have male pins that are in compliance with the MS3116E12-14P standard.

- In the MS standard number, a letter comes after the four-digit number (e.g. MS3116E) which shows the class or the grade of the connector. First, this letter, which can be A, B, E, F, H, J, P, R, or T, indicates the environmental properties of the connector. Second, these letters may even show the type of termination (or Backshell) too. A: general duty

E: grommet seal

H: Hermetic sealed

R: with resilient insulators and sealing " O " ring

P: potted

T: Environment resistant with an accessory thread

Although, these letters may have other implications in other standards.

A few different backshells, that are in compliance with the MIL-C-26482 standard, are illustrated in the pictures below:



- Each part of the military-grade circular multipole connectors may have its own MS code for purchase (such as pins, cable holders, holder bushing, cap, etc.).
- Almost all military-grade circular multipole connectors have caps that are generally chained to the casing or attached to it using a military-grade string and a metal o-ring.
- The pins are often numbered clockwise.
- Recently, Souria and FCI and Amphenol have been merged, forming the largest manufacturers of round connectors.
- Some military-grade circular multipole connectors have EMI and RFI filters integrated into their pins. Almost all manufacturers produce this model too.
- Some round connectors are very small with shell sizes of 2-8. These are known as subminiature connectors and are of the push-pull type. Sungujin, Soltech, Lemo, and HRS are a few manufacturers of this type of connector.

B: general duty with strain relief F: grommet seal with strain relief J: watertight gland seal with strain relief Important Parameters: Gender, plug or jack, the number of pins, straight or right-angle, installation method, connection method, insert arrangement, shell size, backshell configuration, rotation of contacts.

Related Pictures:

 **QWL series (industrial use)**

Some manufacturers:



MIL-C-38999

Souriau (Amphenol), Soltech, ITT Cannon, Sungjin, WPI, Yeonhab, Telegartner, Schaltbau, EMP, Sabritec, HRS

Markings: Often part number

Function: These are generally low-current connectors and are composed of one to three parallel rows and have a maximum allowable current of below 10 A.

Application: These connectors are often available in three configurations; they either have a PCB mount side and a cable mount side, or both sides are either cable mount or PCB mount and are used to directly connect two boards for transmitting data.

Main Specifications:

Various types of these connectors are available, but the following are the best-known: 1. Card Edge

2. D type

3. DIN-41612 type

4. DW

5. FCC 68 Modular

6. FFC & FPC

7. IEEE488 Style (Centronic or 57 Series)

8. Pin Header, Socket, and Housing

9. Power housing and Wire To Wire

10. Shorting & Jumper

11. SMT

12. USB

Application: These connectors are often used to connect card-like boards to a motherboard. Main Specifications:

- The input of these connectors is designed to encompass the edge of a PCB with its parallel contacts.

- The connector pins contact the PCB card either from one side (single-sided) or both sides (doublesided); the same applies for the output pins.

- The single-row type incorporates 5~72 pins while the double-row type has 10~144 pins.

- The casing is often white, blue, black, or green.

- The pitch may be 2.5, 3.2, 4, or 5 mm.

Some of the common types of pins are as follows:

Wirewrap, Faston Terminal, and Formed pin.

- The pins are often gold-plated and the connector can withstand 70 to 250 mating cycles depending on the thickness of its coat.

- The pins may be straight or right-angle with respect to the input.

- The casing of this type of connector is often made of plastic.

Important Parameters: Single or double, the number of positions, color of the casing, pitch, pin shape.



Some manufacturers: FCI, McMurdo. Cinch, Amphenol, Edac
Markings

Application: The D-type connector is often used for connecting a cable to a device and provides robust connection thanks to its fastening screws.

Main Specifications:

- These connectors are available in cable-to-cable, and cable-to-PCB models.

- The military-grade type of this connector is identified by the standard number M24308.

- Some manufacturers: produce non-military models of this connector that are sealed and can withstand military temperatures ranges.

- These connectors often have 9, 15, 25, 37, or 50 pins or positions that are always arranged in two rows.

- The male type is plug while the female is jack.

- The pins may be straight or right-angle with respect to the input.

- Common types of pins integrated into this connector include formed pin, solder bucket, solder crimp, and turned pin.

- D-type connectors may come with a plastic or metal body.

- Some of these connectors have integrated EMI filters on every pin.

- The right-angle models are often PCB mount but the straight models are PCB mount if they have pins, and the solder-bucket types may be either PCB- or cable-mount.

- The cable

- Given that these connectors are produced in compliance with standards, the shell size is similar for the products of different

manufacturers and all of them incorporate nine pins.

- There is also another model that is known as High-Density D-type Connector which incorporates more pins (commonly 15, 26, 44, 62, or 78 pins) that are often arranged in three rows. Important Parameters: Standard or high-density. The number of pins, gender, straight or rightangle, type of the pins, body material, installation, whether incorporating an EMI filter.

 Normal (communication)

 with cover

 Military

PCB type

 High density

 Full plastic

 Water proof



Dual

Some manufacturers: FCI, Mc Mordo, ITT Cannon, Cinch, AVA, etc.

Markings: Sometimes, only the manufacturer name but the military standard numbers are imprinted on the military-grade models.

Application: These connectors are always used for connecting two boards.

Main Specifications:

- These connectors are generally available in two-row and three-row types.

- There are different body configurations for these connectors, including B, C, D, F, G, H, MH, M, and Q. If the body is shortened, the connectors are named proportionally. For example, a B/2 connector has its pins arranged similarly to the B connector (in two rows) but it is half as long as the normal B connector.

- B and C bodies are for data connections, F and D are for average-current applications (6 A), the H type is used in high-current power supplies, and the M type is a combination of the normal pins and coaxial or power pins and is much more common than the other types.

- The pins may be male or female.

- The connector may integrate formed-pin, turned-pin, FASTON,

solder bucket, or wire wrap terminals.

- The terminal may be straight or right-angle.
 - These connectors can be fastened to the board by screw on both ends.
 - Often, these connectors are associated with three terminals but never less than two.
-
- There are some other standards similar to DIN-41612, for example, DIN-41617. Important Parameters: Body type, gender, number of positions, the configuration and orientation of the terminals.

Related Pictures:



DIN-41612 type-B



DIN-41612 type-C



DIN-41617

Some manufacturers: FCI, Harting, AMP, ERNI

Markings: Often only the name of the manufacturer is imprinted on the body (and sometimes the number of pins).



41612 Connector Bodies

Application: The bodies of these military-grade connectors are similar to DIN-41612. Main Specifications:

- These connectors always have an odd number of pins, commonly: 17, 33, 41, 53, and 65.
 - Their bodies are often either blue or black.
 - These connectors always have two rows of pins. A major difference between these connectors and the DIN-41612 model is that they are not plugs or jacks, but their male pins are extended out of their bodies to enter the female part of the connection.
 - Often, multiple metal guides are provisioned at both ends of connectors to prevent mating between the wrong parts.
-
- These connectors are always PCB mount and are available in straight and right-angle orientations.

- Their terminals may be turned pin or formed pin.
 - The international code for these connectors is HE 801~4.
- Important Parameters:** The number of positions, orientation (straight or right-angle), type of terminals, type of guides.
- Related Pictures:**



Some manufacturers: Mc Murdo, Amphenol

Markings: Often the name of the manufacturer and the part number are imprinted on the component or the standard HE number is.

Application: The body of this connector is similar to the D connector, but it may have normal, coaxial, or power pins and is used for data - RF or data - or power applications.

Main Specifications:

- This type of connector shares the same specifications with D-SUB connectors. The only difference is that DW connectors may sometimes have only coaxial or power pins.

Important Parameters: Body type, the number of RF, data, and power pins, terminal type, terminal orientation.

Related Pictures:



Some manufacturers: Harting, AVA

Application: This type of connector is often used for connecting network or phone cables to devices.

Main Specifications:

- This type of connector may be 2, 4, or 8-way.
- These connectors may be male or female, with the male type often being cable mount while the female type may be PCB mount or cable mount. The female PCB mount type of this connector is often right-angle.
-
- The male part is often made of plastic and is colorless while the female part may be made of metal or plastic.

- These connectors may come with a 4/4, 6/4, 6/6, or 8/8 conversion.
- The cable-mount type of these connectors may come with a cover.

Important Parameters: Conversion type, socket or jack, orientation (straight or right-angle), single or double, installation, body type.

Related Pictures:



FCC-68 Modular sockets



Jack



Some manufacturers: MH, Molex, Assmann

Markings: Often without markings.

Application: These connectors are used for connecting FFC cables to the board.

Main Specifications:

- These connectors are available in the DIP and SMD types.
- They may be ZIF or NON-ZIF. The ZIF type allows the cable to be easily put into the connector and lock it in place but the cable must be pushed into the NON-ZIF type.
- The input of this type of connector may be on the side or the top with respect to the PCB.
- They have 2~60 contacts.
- The pins are generally tin or nickel-plated but they are gold-plated in some models.
- Their bodies are generally black or white.
- The center-to-center distance between the contacts is often 2.54 ~ 0.3 mm.
- For more information on the characteristics of the FFC cables check the 7-3-4b section of this book.
- The SMD type of the ZIF connectors is either top-contact or under-

contact. In side-input models, the connector lock is often placed at the input but some manufacturers: (e.g. Omron) place the cable lock at the end of the connector.

Important Parameters: The number of contacts, pitch, the type of contacts, ZIF (top or under) or NON-ZIF, installation (SMD or DIP), and side or top.

Related Pictures:



Some manufacturers: Omron, Molex, AVA, etc.

Markings: No markings.

11-7-7 IEEE488 Style (Centronic or 57 Series)

Application: Often used to connect devices such as printers or other accessories.

Main Specifications:

- **Their bodies are similar to D-SUB connectors.**
- **They may have 14, 24, 36, or 50 pins.**
- **They are available in male and female types.**
- **The embedded pins are similar to cards that can be put inside the female card edge.**
- **They may integrate PCB mount, solder bucket (cable mount) or special ribbon cable terminals.**
- **The connector may be straight or right-angle. (AVA images for all models).**
- **The PCB mount type of this connector is often right-angle.**
- **Some models have a metal body.**
- **The cable-mount type of these connectors may come with a metal cover.**
- **Often, in order to make a robust connection, these connectors are made with integrated locks that are composed of spring metals placed on the two sides of the connector.**

Important Parameters: Gender, the number of pins, installation method, orientation, PCB-mount or cable-mount, cover.

Related Pictures:



Centronic IDC-Centronic

Some manufacturers: AVA

Markings: Sometimes the manufacturer name and code.

11-7-8 Pin Header, Socket, and Housing

Application: Often used for connecting two boards or a wire or cable to a board.

Main Specifications:

- The non-directional types are often similar to a comb, hence, they are sometimes referred to as comb connectors.
- Male pin headers may have DIP or SMD PCB-mount terminals.
- Sometimes, long male pin headers (longer than 20 mm) terminals have a spacer and are used for connecting two boards.
- Sometimes, male pin headers have turned pins but generally, they have formed ones.
- Male pin header connectors are often non-directional and without a locking mechanism.
- Generally, two types of pins are used in female pin header connectors. One type is similar to

- and encompasses the male terminal from two sides while the other type secures the male connector pin from three directions by springs. The latter is definitely a better option since it provides a robust connection that can endure more mating cycles.

- header

- Similar to their male counterparts, socket header connectors are also non-directional and PCB mount.
- Directional pin headers have an obstruction at least on one side making the connector directional. Sometimes, the obstruction features a protrusion that serves as a lock.
- Directional connectors are also known as communication or wafer connectors.
- Most pin header connectors are non-directional and the directional types are known as communication connectors.
- Often the female side of the communication connector does not have a

PCB mount terminal and is a housing (normally without pins). The wire is to be soldered or crimped to the pins and the pins are to be installed within the housing.

- **Communication connectors also may have DIP or SMD PCB mount terminals.**
- **Pin header and communication connectors may be straight or right-angle (males and sockets); however, housings are only straight.**
- **These connectors may have 2~100 positions.**
- **Both single- and double-row types of this connector are available.**
- **The pitch is typically 1~5.08 mm. 1 mm pitch connectors are often SMD while 3.96 and 5 mm pitch connectors often have thick terminals and are used as power connectors.**
- **The contacts may be tin- or gold-plated with various thicknesses.**
- **The overall length of the pin in male connectors may be 5~50 mm.**
- **These connectors are made in various colors but the male pin header and the socket are generally black.**
- **The socket may have an SMD terminal.**
- **The right-angle socket may have one or two (DIL) rows of terminals. The DIL type is similar to an IC in appearance.**
- **Single-row connectors are single-decker and double-row connectors are double-decker.**



- **Various housing pins are available with different configurations.**
- **Catalogs often specify the opposite connector and the model of the pins.**

Important Parameters

Male: Directional or non-directional, locking mechanism, straight or right-angle, the number of positions, pitch, the number of rows, pin plating, the overall length of the pin.

Female: Socket or housing, mating side, mating mechanism, the number of positions, pitch, the number of rows, directional or non-directional, locking mechanism, color, the socket joint cover or terminal cover in the housing.

**Housing pin or terminal: Coating, body material, body configuration.
Related Pictures:**



wire to board



Terminal(crimp)



socket header



Pin Header

Some manufacturers: AVA, Molex, Assmann, Fischer Markings: Often without markings.

Application: Often used for connecting the power or connecting two cables. Main Specifications:

- Both male and female sides are housings only the one terminal is male and one is female.
- One of the connectors is a jack and the other is a plug.
- Often both sides are directional and have locks,
- Generally, there are a limited number of positions.
- Power, or high-voltage, connectors often have larger terminals that are further apart.
- They often have one or two rows.
- Sometimes, both sides have protrusions that help separate the pieces.

Important Parameters: Gender, the number of pins, the number of rows, pitch, protrusion, directional or non-directional, locking mechanism.

Related Pictures:



Some manufacturers: Molex, AVA

Markings: No markings.

Application: These components are used to short-circuit two points on a board or a connector.

Main Specifications:

- Jumpers are often produced on pin header connectors or two PCB mount pins with standard pitch.
- Shortings are made for sockets.
- Therefore, jumper is female and shoring is male.
- Often made in black, blue, green, red and yellow.
- Shortings often have handles while, due to their small dimensions, jumpers usually don't.
- The pitch is often 2.5 or 5 mm in jumpers while it may be 5, 6.35, 10.16, or 12.7 mm in shortings.
- Jumpers are often open on top (their pins are visible and accessible for installing a test device) but closed models are also available.

Important Parameters: Jumper or shorting, color, pitch, top configuration.

Related Pictures:

 **Jumper**

 **Shorting**



Shorting Plug

Some manufacturers: Molex, Assmann, Fischer, etc.

Application: This component is used for connecting two boards.

Main Specifications:

- Both male and female components are SMD, therefore, a distance of 1~1.5 mm can be achieved between the two boards.
- The component may be 10~100-way.
- The pins may be tin or gold-plated.
- The pitch is often 0.5 mm.

Important Parameters: Pitch, the number of positions, gender.

Related Pictures:



**SMT (microleaf) Some manufacturers: HRS, AVA
Without markings**

Application: For data or cable connection that allows fast insertion and detachment. In fact, USB connectors are known as fast connection.

Main Specifications:

- Often, these connectors are available with A and B body types with the B-type (also known as miniUSB) being slightly smaller.
- USB connectors often have four positions.
- Sometimes, they are found with two rows (two in one package).
- These connectors are often made in black or beige.
- The contacts are often gold-plated.
- The pins may be DIP or SMD and the DIP pins may be straight or right-angle.
- Some models are cable mount.

Important Parameters: Body type, gender, straight or right-angle, installation (PCB or cable mount), DIP or SMD, body length, the number of rows.

Related Pictures:

 USB type-B mini

 USB type-B

USB Type-A



Some manufacturers: Conec, Molex, AVA, Cypress ind.

These connectors are available in three types: 1. Connector Adapter
Hybrid connector.

Application: Connectors are often used in HF or higher frequency applications. **Main Specifications:**

- These connectors are diverse in shapes, application, operating frequency, etc. The most important types of connectors in this group are:

7mm, BNC, Conhex, FME, MCX, MMBX, MMCX, MMT, N, SMA, SMA B, SMB, TNC,

Twin Axial, UHF.

- The male and female parts of these connectors are sometimes threaded and may be fastened by rotation and sometimes they are pushed in each other, or fastened with a half turn.

- The plug is often male whereas the jack is female .Some models are normally jack is male.

male and female parts. For example, if BNC-Plug is male, BNC-Plug-Reverse is female.

- Often all the above groups have cable mount, panel mount, PCB mount, straight, right-angle, tinand-nickel-plated, and gold-plated types.
- Generally, all groups have the following joints behind the connector: Cable Clamp, Cable Crimp, Solder pot, For Semi-rigid, PCB mount, Strip line.
- Often, the panel-mount models are Free Panel mount, Panel narrow and/or square flange.
- Only RF cables may be connected to these connectors.
- These connectors are produced in different lengths for various applications.
- In some catalogs, the suitable cable for the connection is specified as follows.

5/50/S

Which means: Cable diameter = 5mm, Impedance = 50 R, Shield pattern = S.

- The
- Each cable mount connector may accept multiple types of RF cables. This is specified in the catalog as one of the main specifications.
- RF connectors often must be installed and prepared based on instructions that are given by the manufacturer (the reason is that RF connector is sometimes sold in separate parts).

Important Parameters: Gender, connection method behind the connector, straight or right-angle, installation method, length, impedance, body coating, cable diameter (for the cable-mount type), or the names of related cables.

Related Pictures:

 MCX plug

    MCX Jack

 BNC male & female

MMT female plug

 MMT male receptacle

 MMT

MMBX PCB Receptacle

 MMBX Cable Plug

 MMBX adapter

 SMC

 SSMA

 N male plug

 N female receptacle

 N-TEE Adapter

 N Adapter



UHF



Some manufacturers: Radiall, S Conn, Rosenberger, Telegartner, ITT cannon, Tyco, Amphenol, Huber Suhner, Midwest Microwave.

Markings: Often the manufacturer name and part number, sometimes without markings. **Function:** This connector is, in fact, a combination of two different (or similar) types of connectors and is intended for mid-way connection.

Application: Often used for matching two RF systems an adapter is used at the point their cables are connected.

Main Specifications:

- The most important characteristic of this connector is the type of its conversion that can be the same on both sides (e.g. SMA/SMA) or different (e.g. N/SMA).
- Either side of the conversion may be male or female.
- These are often mid-way, cable-mount connectors but their panel-mount models are also available.
- These connectors are produced in different lengths for various applications.
- The connectors may be plated with nickel, silver, or gold.

- These connectors (converters) may be straight or right-angle.
- TEE Adapter is a three-way converter with the characteristics mentioned above but all three connectors are similar.

Important Parameters:

Two-way converter: Type of conversion, gender of each side, installation method, length, plating, straight or right-angle.

TEE. The type of connector, gender, body plating.

Related Pictures:



TEE ADAPTER (SMA)

 Some manufacturers:   SMA/SMA Adapter

 BNC/SMA

Radiall, Rosenberger, Telegartner, S Conn, ITT cannon, Tyco, Amphenol, Huber Suhner, Midwest Microwave.

Main Specifications: The following models are very common:

 DC BLOCK

 Coaxial Attenuator

 Phase shifter

 Coupler

Coaxial Termination



Coaxial Rotary Joint



- It is advised to consult the respective catalogs for these connectors in order to make the right choice.

- The operating frequency is one of the most important parameters regarding these models. **Important Parameters:**

Attenuator: Type of connection, power, attenuation.

Termination: Type of connection, gender, power.

Rotary Joint, Phase shifter, Coupler, Circulator: Consult the catalog.

Some manufacturers: Radiall, Rosenberger, Telegartner, S Conn, ITT cannon, Tyco, Amphenol, Huber Suhner, Midwest Microwave.

These connectors may be classified into the following groups:

- 1. Crimp Terminal 2. IC test Clip / extractor 3. Panel mount terminal (Fixing or Binding Post)**
- 4. PCB Spade 5. Test panel mount terminals and Banana connectors**
- 6. Test Socket**

Main Specifications:

- These cable-mount terminals are often installed within communication housing connectors, but some of them may be used separately.**
- They are very different in shape.**
- They are often made of phosphor-bronze or brass.**
- The end of the wire is always pressed to the ends of the rivet-type crimp connectors.**
- Riveting often requires particular machines that are recommended by the manufacturer.**
- Similar to the solderable connectors, the wire may be also soldered to the rivet connectors.**
- The solderable connectors have a hollow tube at the end to encompass the wire and tin.**
- The models that are used inside housings do not have a particular name but the stand-alone models are known by the following names: Ring, Push on receptacle, Push on tab (or blade), Piggy back, Pin, Bullet (male or Female), Fork, Butt.**
- These (stand-alone) terminals may be right-angle.**
- In models such as Ring and Fork, that integrate a screw, the internal hole diameter is also very important.**
- Some models integrate an insulator to prevent connection with other sections. This insulator is commonly available in blue, yellow, red, white, or is colorless.**
- The insulated models are not used inside a housing and are standalone.**
- The colors yellow, blue, and red in insulations indicate the standard**

diameter (AWG) of the wire that is to be connected to them (Table on the next page).

- Terminals specific to housings are often rolled. There are even special devices for installing the wire in them and placing them in the housing.
- The terminals may be plated with tin, nickel, silver or gold.
- A stranded 19/0.15 wire is composed of nineteen intertwined, 0.15mm-dia, solid wires.
- The rated current for red is around 10 A, for blue is around 15 A, and for yellow around 24 A.
- Therefore, the colors also indicate the maximum allowable current.

Important Parameters:

Body shape, insulation and its color, straight or right-angle, AWG code of the wire attached to it, body material, hole diameter for models such as Ring, dimensions.



The names of the groups in the picture above (from left to right): Push-on receptacle (first to third groups), Push-on Tab (blade), Piggyback, Push-on receptacle (right-angle).

Crimp connectors and their respective wires Insulation Color

Wire Specifications_{Red Blue Yellow}

Wire Size (mm²) 0.25 - 1.65 1.04 - 2.63 2.63 - 6.64 Solid wire diameter 0.57 - 1.44 1.14 - 1.82 1.82 - 2.89_(mm)

AWG Equivalent 22 - 16 16 - 14 12~10 SWG Equivalent 29 - 17 17 - 13 11~6 Suitable Wires and Cables

19/0.15 19/0.3 19/0.45

13/0.2 7/0.5 44/0.3

16/0.2 21/0.3 7/0.85

19/0.2 30/0.25 56/0.3

Stranded

14/0.25 19/0.335 65/0.3

24/0.2 63/0.2 37/0.4

19/0.25 28/0.3 159/0.2

32/0.2 35/0.3 84/0.3
40/0.2 51/0.25 7/1.04
19/0.3

Solid

1/0.9 1/1.38 1/2.25
1/1.13 1/1.78

AWG = American Wire Gauge SWG = Standard Wire Gauge Related pictures:



Crimp Terminals



Blade Bullet



Butt Fork



Ring



Pin

Some manufacturers: SAFAK, TYCO, STOKO, Thomas & Betts, JST

Application: These components are used to test terminals or to remove ICs. However, these components are becoming obsolete as SMD ICs are becoming more common.

Parameters: The number of IC pins.



IC text clip



Images: IC extractor

Manufacturers: 3M

Application: These components are often used for connecting wires to connectors (often in military applications).

Main Specifications:

- Often available in two types.

Push-on: Applying pressure reveals the wire input that encompasses the wire and the connector is locked in place as the pressure is removed.

Screw-on: The wire is fastened at the tip by twisting it.

- These components are available in insulated and non-insulated

models.

- Their length is often between 30 to 50 mm.
- They are always mounted on the casing of the device.
- The diameter of the terminal is often 4-5 mm and a suitable hole must be drilled into the casing.
- Their cap is often circular or square.

Important Parameters: Insulation color, length, cap, the diameter of the cut on the panel, screw-on or push-on.



Images:

Some manufacturers: Cliff, Abatron

Application: This component is used for connecting push-on receptacles. **Main Specifications:**

- PCB tabs often incorporate one or two terminals for mounting on the board.
- The blade may be 6 to 12 mm long and 2.8 to 6 mm wide.
- They generally withstand a current of 1~10 A.
- Their casing is often tin-plated but gold-plated models also exist.
-
- Some models are right-angle.

Important Parameters Dimensions, body shape.



Some manufacturers: Stoko, SAFAK, Vogt-AG

Without markings

Application: For temporary tests or measuring a parameter or as the output of measurement devices and power supplies.

Main Specifications:

- The casing is often black and red (for negative and positive terminals) but sometimes it is made in white, blue, or green.
- The tip of the wire is known as Banana.
- The diameter of the component may be 2, 4, or 6 mm.
- The female type is panel-mount while the male is cable-mount.

Important Parameters: The diameter of the socket or banana, the color of the casing, the diameter of the seat (for the female type), length (for

the female type).

Related Pictures:

 **Socket or Terminal (female)** 

Banana (male)

Manufacturers: Hirschmann Markings No markings.

Application: Used for changing the condition of the device for testing purposes.

Main Specifications:

- The female type is PCB-mount while the male is connected by hand and is not attached to a wire.
- Some models incorporate an LED to show changes in the position.
- The female type is available in top- and side-entry models.

Parameters: The diameter of the hole in the female type or the rod in the male type, integrated LED, LED color, top- or side-entry.

Images:



Shorting test plug Test Socket



Manufacturers: Hirschmann

Markings: Sometimes the name of the manufacturer.

Application: For connecting wires or optical fibers to circuits.

Main Specifications: These connectors are often available in the following models.

 **Detector:**

 **Emitter:**

Transceiver:

 **Transmitter:**

 **EC fiber optic:**

FC fiber optic:

 **LC fiber optic**

 **SC fiber optic:**

ST fiber optic:



Manufacturers: Infineon , Avago

Markings: Sometimes the manufacturer name and part number, sometimes without markings. Displays are often available in four types: VFD, Lamp display, LCD, and LED display.

Function: This type of display is composed of small luminous spots (small fluorescents) that emit light under an applied voltage.

Application: This type of display may be used at very low (-40 °C) or high temperatures (+85 °C) or under vibration (military conditions).

Main Specifications:

- These displays are often very suitable for industrial or military applications or in cars (=40~+85 °C).
 - This type of display can generally withstand vibrations very well.
- Generally speaking, three types of sleeves are available:

1. Seven Segment 2.Alphanumeric 3. Dot Graphic Important Parameters

- Seven-segment: The number of digits, number of dots, digit color, background color, the number of terminals, type.
- Shared power, dimensions of the digits.
- Alphanumeric: The number of characters and lines, digit color, module dimensions, display dimensions.
- Dot Graphic: The number of dots, the length and width, module dimensions, display dimensions, dot dimensions.

Related Pictures:



VFD, Graphic



VFD, Dot graphic



VFD, Alphanumeric Some manufacturers: Noritake-Itron, Samsung, Futaba, IEE

Markings Manufacturer name and product number.

12-2 Lamp Display

Function: This type of display works similar to a filament lamp.

Application: These displays are often used in military applications due to their high quality, resistance to harsh environments and vibration.

Main Specifications:

- Often similar to seven-segment in appearance and are produced in small dimensions.
- Visible in sunlight.
- All numbers, letters, symbols, etc. may be fabricated and displayed on this type of display.

Important Parameters: The shapes of the displayed characters, character dimensions, display dimensions, voltage, current.

Related Pictures:



Some manufacturers: Wamco

Function: Applying a voltage to a panel that encompasses liquid crystal reveals characters and images.

Application: This type of display is used as a general display in all types of devices (calculators, monitors, measurement devices, cell phones, etc.).

Main Specifications:

- LCDs are available in black-and-white, color, green, blue, and other
- Generally, LCDs are either alphanumeric or graphic.
- Attaining low operating temperatures for LCDs is quite difficult and manufacturers make their best products for the temperature range of -30 to +85 °C.
- Touch LCDs are also available that transmit the selected data to the processor as the screen is touched. However, these displays are, in fact, composed of a touch screen installed over an LCD panel.
- In the graphic LCDs, often, the length and width are divided into a number of points as follows: width: 32, 64, 128, 200, 240, etc, length: 128, 240, 264, 320, and 640.

- LCDs are often associated with either a twelve o'clock viewing angle or a six o'clock viewing angle (viewing from top or bottom).
- Some LCDs have their driver circuit installed on them.
- The backlight may be LED, EL, or CCFL.

Important Parameters:

Alphanumeric: The number of characters and lines, background color, backlight type, backlight color, LCD dimensions, display dimensions, character dimensions, viewing angle, operating temperature.

Graphic: All the above plus the number of dots in the length and width of the display instead of character and line.

Related Pictures:

 LCD 7-seg.

 Display OLED

 Alphanumeric LCD



Graphic LCD

Some manufacturers: Batron, Hitachi, Varitronix, etc.

Function: This type of display is composed of LEDs that are arranged in a particular configuration. **Application:** Counters, digital displays and direction displays in elevator cabins or doors, etc. **Main**

Specifications:

- These displays can be classified into five major groups: seven-segment, dot matrix, backlight panel, bar-graph, and starburst.
- Seven-segment LEDs are the best known and most common types of LED displays and are generally used for displaying numbers or letters by arranged LEDs.
- Often used for displaying the numbers 0 through 9, however, some letters may be displayed with them too.
- Often available in red and green and sometimes in orange.
- These displays are made in common-anode and common-cathode models.
- Dot matrix LED displays are composed of multiple LEDs that are placed side-by-side and can be used to make all types of characters.

- Starburst LED displays have all the features of seven-segment displays in addition to being capable of showing alphabets.
- Bar-graph LED displays are often composed of a number of monochrome or multi-color LEDs that are arranged on a board and enable columnar display.

Important Parameters:

- For seven-segment and dot matrix LED displays: The number of digits, the number of dots, digit color, background color, the number of terminals, type of power, digit dimensions, casing dimensions, the code displayed by the digit.
- For backlight panel LED displays: Background color, casing dimensions, type of the display, the number of digits, the width of the character.

Related Pictures:



7. SEG



DOT MATRIX



LED Bargraph



LED backlight panel

Some manufacturers: Avago, Kingbright

Function:

Applying voltage to the motor rotates the blades providing an airflow.

Application:

Cooling and air conditioning systems such as CPU fan and other fans inside a computer's case, etc..

Main Specifications:

- Fans are available in AC and DC types (two types of operating voltages),
- They are also available in Sleeve and Ball (ball bearing) types.
- Generally, fans have square or round bodies.
- Fans are available in various sizes, including:
25x25 , 30x30 , 35x35 , 40x40 , 45x45 , 50x50 mm
- General thicknesses that can be manufactured: 6 , 10 , 15 , 20 , 38 mm
- DC power voltages: 5, 12, 24V
- They often incorporate four blades but sometimes manufacturers use

more blades to increase the airflow.

- Blower fans are designed to provide airflow in a certain direction.

Important Parameters

Voltage type, body shape, body dimensions, power, sleeve or ball, sometimes the generated noise.

Related Pictures:



Blower

Some manufacturers:

PAPST, Sunnon, Panasonic, NMB, etc.

Markings

Manufacturer part number, voltage, manufacturer name, and sometimes the rated current or power. This class of components can be divided into three groups:

1. Fuse 2. Arc Suppressor 3. Transient Suppressor Transient Suppressor

Function: Breaks the connection when the current exceeds the allowable limit.

Application: For protecting electrical and electronic circuits against short-circuits or over current. Main Specifications:

- Resettable and disposable fuses are the two major types of fuses.
- Resettable Fuses: The ionic bonds inside these fuses are broken when excess current is passing through but they are reset to their original state when the current returns back to normal. These fuses are known as polyswitch or resettable fuses.

Disposable Fuses: These are the most common fuses and are cheap.

- The most common types of fuses are: TR5 (car fuse), ceramic, glass, wire-end, SMD, screw-type, and miniature circuit breaker.
- Miniature circuit breaker and screw-type fuses are often used for household and industrial electrical applications while the other models may be used in electronic circuits.
- Miniature circuit breaker is resettable and is used in household and

industrial electrical applications.

- Screw-type fuses are available for a range of currents from a few mA to tens of A.
- Thermal Fuse: These components are covered in Section 22-8-3 (Thermal Switch).
- In terms of the speed of response, fuses may be very fast (FF), fast (F), medium (M), or with delay (Time Lag).
- Car fuses may have a rated current of 5, 10, 15, 20, 25, or 30 A.
- Glass, ceramic, and SMD fuses are the most common types of fuses in electronics and are made for currents of up to 60 A. These fuses are often available in the following standard sizes: 20*5mm, 25*6.3mm, 32*6.3mm, 15*5mm (the larger number is the length and the smaller one the diameter of the fuse.).
- The TR5 model is often used in military applications.
- Car fuses are often produced in the following standard colors that represent the rated current of the fuse:

**5A: Orange or cream 7.5A: Grey 10A: Red 15A: Blue 20A: Yellow
25A: Colorless 30A: Green**

Parameters:

Disposable Fuses: The mechanism, nominal current, voltage, dimensions (the case for SMD).

Polyswitch Fuses: Hold current, voltage, dimensions or the diameter.

Related Pictures:

Miniature circuit breaker

 **SMD**

 **GLASS**  **CERAMIC**



Automotive fuse (car fuse)

Some manufacturers: Conquer, Raychem, Schurter, Bussmann

Markings Often, the rated voltage and current is imprinted on the fuse.



Polyswitch

Function: These components are opened up when high (many kV) voltages are applied (cases such as lightning) and protect the circuit, some surge arresters are used for AC or DC voltages. **Application:** For protecting the circuits connected to antennas, in surge arresters, and in tall buildings, or used to protect circuits against overvoltage in AC or DC applications. **Main Specifications:**

- These components are often made PCB-mount or as a connector.
- Surge arresters are often installed at the closest point to the circuit connected to the antenna. **Important Parameters:** Nominal voltage, dimensions, maximum voltage.

Related Pictures:



Surge arrester

Some manufacturers: Normal: Siemens (Epcos), connector shape: Radiall, Midisco Markings Manufacturer name and product number.

Function: Transient suppressors are placed in parallel with the input voltage (similar to Zener). **Application:** Used for protection against high-voltage, strong pulses (such as lightning) and other instantaneous or induced surges inflicted upon the circuit (protection against EMC, ESD, EMP).

Main Specifications:

- These components are made in connector and diode types.
- The transient-voltage-suppression diode is available in both uni and bi-directional types. **Important Parameters:** Operating voltage, nominal peak pulse power, pulse duration. **Related Pictures:**



Transient suppressor Dip & array

Some manufacturers: Fischer, Littelfuse

The following six groups are the most famous electronic component holders: Cable, Microphone, Battery, Fuse, Lamp, and LED Holders.

Function and Application: Plastic or metal components that are used to fasten and secure cables in air, on the casing of a device, or a wall.

Main Specifications:

- Cable holders are generally classified into glands, p-clips, and cable-ties.
- The gland holder is intended for securing cables in holes drilled on the casing of devices.
- The p-clip holder is intended for securing cables on walls.
- The cable-tie is used to secure and hold multiple cables or wires side-by-side.

Important Parameters:

Gland: Length, body material, fitting cable diameter, color.

P-Clips: Fitting cable diameter, the diameter of the hole, installation screw, color, the width of the clip.

Cable-tie: Length, width, threaded length, color.

Related Pictures:

 Gland

 Cable-tie



P-clip

Some manufacturers:

Gland: Lappkable

Cable tie: SAFAK

P-clip: Larpro, Hall-fast

Sometimes, holders are used for small microphones.

Important Parameters: Microphone size, dimensions, terminal location. Images:

 Microphone holder (SMD)

Manufacturer: Panasonic, Greatrubber

Holders are used for batteries that do not have terminals or no wire is soldered to them. A battery strap is used for 9 V batteries.

 **Important Parameters:** Type of battery, the number of batteries,

integrated terminal or battery strap. Images:



Some manufacturers: Bulgin, AUK

15-4 Fuse Holder

Function: Plastic or metal components that encompass the fuse.

Main Specifications:

Fuse holders are made with respect to the type of the fuse and are available in the following models: TR5, SMD, Inline, CLIP, BOX, Panel-mount, PCB-mount, Rail-mount, and Screw-type.

- Rail-mount fuse holders are used for miniature circuit breaker (household).
- Panel-mount fuse holders are associated with different caps, including: Screw cap, bayonet release (the holder must be pushed in and then twisted half a turn to open), and finger release (must be twisted by two fingers to open).
- There are also combination models, such as: Bayonet/Finger release, etc.
- Clip holders are used for glass or ceramic fuses and may come with two terminals or no terminals. One clip must be installed on each end of the fuse. A protrusion is embedded in some fuse holders (ear type) that help better secure the fuse.
- Normal panel-mount fuse holders are available in Circular, one or two flat side and PCB mount.
- Some fuse holders are sealed with an O-ring.

Important Parameters

BOX: Box and fuse dimensions, rated current.

Clip: Fuse diameter, rated current, terminal, ear type.

PCB-mount: Cap shape and model, PCB-mount or panel-mount, fuse dimensions, rated current, and the overall length.

PCB-Mount open: Terminal configuration, rated current, the number of fuses, fuse dimensions, terminals space.

SMD: Rated current, fuse case, fuse-holder dimensions.

TR5: Installation, diameter, case.

Related Pictures:

 Fuse clip

 In-line fuse holder

 Fuse holder, panel and PCB

 Fuse holder, open frame



TR5 fuseholder Vertical and Horizontal

Manufacturers: Conquer, Schurter, Bussmann, Littelfuse, Wickmann
Markings

Panel

Other models: Often either without markings or only bearing the maximum allowable current. **Function and Application:** Often used for securing small lamps on a panel or a board. **Main Specifications:**

- The most common models are:

Jam Nut Panel mount

Snap-in Panel mount

PCB-Mount

- Panel-mount holders may come with a flat or domed lens. These are available in colorless, green, blue, red, yellow, and orange.

- Often, the lamp base that is placed inside the holder is either of the screw-type or the bayoneted type.

- Lamp holders may be made of plastic or metal.

- Solder Lag lamp holders are mounted on the board as SMDs.

Important Parameters:

Panel-mount: The body material, lens type, lens color, base diameter or standard, body length, the corresponding base, the diameter of the installation panel hole.

PCB-mount: Dimensions, the type of the lamp base, body material, lamp diameter, pitch. **Related Pictures:**

2-Pin

 HID

 Incandescent

 **Halogen
Fluorescent**



Panel mount Some manufacturers: Arcolectric, Bulgin, 1000 Bulbs

Function and Application: Often used for securing LEDs on a panel or a board. **Main Specifications:**

The most common models are:

- Jam Nut Panel mount
- Snap-in Panel mounts
- PCB-Mount
- These holders are available in the market for all size of LEDs, including: 8mm, 5mm, 3mm, etc.
- These holders are often made of metal or plastic.
- The LED base may be recessed, leveled, or protruded.

Important Parameters: Type, material, LED size, length, diameter, panel cut diameter.

          **Manufacturers:** 

Arcolectric

These parts insulate components by separating them from other surfaces and prevent electrical connection. Insulations may be used as jackets.

Insulating parts can be classified into four groups:

1. Heat shrink
2. Insulating bush
3. Ferrite core insulating pads
4. Thermal pads

Function: These are flexible plastic components and are generally hollow.

Application: Often used to cover wires, cables, their tips, or at cable-cable, or cable-connector joints. Sometimes, they are only intended for covering but the heat shrink tubings are used to also secure the joint.

Main Specifications:

Generally speaking, three types of sleeves are available:

- Binding Sleeve

- **Fiberglass Sleeve**
- **Heat Shrink Tubing**
- **Binding sleeves are actually plastic tubings (often colorless) that are placed around wires or cables so the joint is protected against damages or being there are color models too.**

Fiberglass sleeves are similar to binding sleeves. Their only difference is that fiberglass sleeves can withstand higher temperatures; therefore they are used in devices that work at a high temperature (such as heaters).

Heat shrink tubings shrink when heated (at 100 °C or above) with their internal diameter reduced with a ratio of 2:1, 3:1, 4:1, or 6:1.

- **The 2=>1 shrink ratio is the most common.**
- **All heat shrink tubings have both adhesive and non-adhesive types.**
- **Some manufacturers: produce sleeves with special configurations, including right-angle.**

- **Some manufacturers: produce sleeves with special configurations, including right-angle sleeves (that are straight prior to heating, and bend after that) or three-way sleeves.**

- **Heat shrinkable sleeves are made in all colors.**

- **Some standard diameters are presented in the following for 2:1 heat shrink tubings (the numbers are fixed here):**

1.2 ==> 0.6mm , 1.6 ==> 0.8mm , 2.4 ==> 1.2mm , 3.2 ==> 1.6mm 4.8 ==> 2.4mm , 6.4 ==> 3.2mm , 9.5 ==> 4.7mm , 12.7 ==> 6.35mm 19 ==> 2.4mm , 25.4 ==> 12.7mm , 38 ==> 19mm , 50.8 ==> 25.4mm 76 ==> 38mm , 102 ==> 51mm

Important Parameters Color, shrink ratio (the diameter before and after heating), shape (normal, rolled, right-angle, etc.), adhesive, length.

Related Pictures:



Heat shrinkable



Some manufacturers: Alpha, Raychem, T & B

Markings: Often the name and product number, sometimes, the shrink ratio.

Function and Application: Cylindrical plastic parts that are placed inside the holes in the casings of some transistors (e.g. TO-220, TO-247, etc.) and the installation screw isolate the component from the casing.

Main Specifications:

- These bushes are made for various casings; therefore, their internal and external diameters may vary.
- They are typically black, white, or colorless.

Important Parameters: Package number of transistor, bush color, the internal and external diameters.

Related Pictures:

 **Manufacturers: Markings No markings.**



Insulating bush Assmann

16-3 Ferrite Core Insulating Pad

Function and Application: These components are typically made of talc and are used to insulate the core and the board from each other,

Main Specifications:

- These pads may be made of talc, fiberglass, etc.
- These pads are used for various types of cores, including the RM series.
- These pads are available in various configurations, including square, oval, round, etc. **Important Parameters: Pad material, configuration, core standard number.**

Related Pictures: Insulating Washer



Manufacturers: EPCOS

Markings No markings.

16-4 Thermal Pad

Function: Silicon, talc, or sponge plates that easily conduct and dissipate heat.

Application: These components are often placed between transistors or amplifiers and heat sinks. **Main Specifications:**

- Thermal pads are available as thermal sheets and also cut according to the standard dimensions of the transistor or the component.
- Thermal sheets may be made of silicone or plastic.
- Cut thermal pads are generally made of talc, sponge, or silicone.

Important Parameters: The material is important for both types of pads, the dimensions are important for the thermal sheets while the standard case of the component is an important factor regarding cut pads (e.g. TO-220).

Related Pictures:

Thermal pad



Thermal sheet

Some manufacturers: Fischer, Assmann, MEC

Markings: No markings.

Function: Lamps are composed of filaments or cathodes that are housed in vacuum casings and emit light as electric current passes them.

Application: Anywhere that lighting is required.

Main Specifications:

- Electric lamps are often available in filament and neon types.
- Filament lamps may work with AC or DC voltage; here we address the DC type.
- Filament lamps are made for a range of operating voltages, including 2.5, 5, 6, 9, 12, and 24V.
- Filament lamps are generally available in bulb, candle, and tubular shapes.
- Filament lamps are available with wire, screw, and push-on bases.
- Often, filament lamps have clear bulbs but color bulbs may also be found among the products.
- The operating voltage of neon lamps is typically 220 V.

- Neon lamps may come with or without a holder.
- Neon lamps with integrated holders are often panel-mount and may be of the screw, push-on, or the bayoneted type.
- Some neon lamps incorporate a series resistor in the holder.

Important Parameters

Typical DC lamps: Operating voltage, bulb diameter or dimensions, the length of the lamp, base type, power, color, bulb shape.

Neon Lamps (without holder): Voltage, lens color, holder color, light color, installation method on panel, holder dimensions, lens shape, integrated resistor.

Related Pictures:

 Lamp indicator (signal)

 Neon indicator

 Bi-pin lamp Halogen

 Oven

 Xenon

Filament

 Slide

 Wedge-base  

Wire-ended

Some manufacturers:

1000bulbs, Intl-lighttech

Markings

DC lamps: Generally, the voltage, power, and current.

Neon Lamps: Without markings

Function:

Hybrid components are actually composed of multiple components such as IC, resistor, capacitor, transistor, etc. that are integrated into a small package for a new application.

Application:

Hybrid components are used in all fields and can be found in many groups that will be readily discussed.

Main Specifications:

- Some major groups are (left: the name of the component, right: the name of the manufacturer): Active Filter
Amplifier

Attenuator

Attenuator/Switch

Converter

Coupler

DC Power Controller Discriminator

Divider

Evaluation Board

Interface

Isolator & Circulator

Limiter

Mixer

Modulator & Demodulator Oscillator

Phase detector

Phase Shifter

Power Splitter Combiner Receiver

RF Diode Switch

Ring Generator

Splitter / Combiner

Switch (active)

Synthesizer (Active)

Transmitter

VCO

Wave guide

- Considering the various shapes and standards of these components it is recommended to consult the ==> Murata

==> Minicircuits, Mitsubishi, Analog Device, M/A-Com

==> Minicircuits, Anaren, Radiall

==> Minicircuits

==> Pico, Powermate, Vicor, TI

==> Minicircuits, Anaren, M/A-COM

==> Teledyne

**==> Murata, Quartztek
==> Midwest Microwave
==> AD, M/A-Com, Avago
==> Zarlink, Silicon Labs, CP Clare
==> Valvo**

**==> Minicircuits
==> Minicircuits, M/A-COM, MITEQ
==> Minicircuits
==> Minicircuits
==> Minicircuits
==> Minicircuits
==> Minicircuits
==> FALCOM
==> Murata
==> Power dsine (Microsemi)
==> Minicircuits
==> Minicircuits, Analog Device, M/A-COM
==> Minicircuits
==> AD, Maxstream
==> Minicircuits, Murata, Z - COM
==> Midwest Microwave, microwaveeng**

Related Pictures:



- The important parameters and markings can be found in the components datasheets. Here, we discuss DC motors including stepper motors and servomotors.

Servomotor:

These motors rotate at a constant speed for a fixed DC voltage. Their speed decreases with decreasing the voltage, and the direction of the rotation can be changed by changing the polarity of the applied voltage.

Stepper Motor:

Each input voltage pulse rotates these motors to a defined angle, and

the direction of the rotation can be changed by changing the direction of the input pulses.

Important Parameters:

Body size, voltage, and holding torque.

 **Stepper motor**



Manufacturers:

Sanyo Denki, Premotec, Mclennan, Maxon motor

Function:

Boards made of fiberglass, Teflon, plastic, etc. on which electronic components can be mounted.

Application:

Almost all electronic components must be mounted on a PCB (except for those components that are supposed to be mounted on the casing).

Main Specifications:

- The most common groups are

Phenolic

Flexible

Teflon

Teflon-Epoxy

- The FR4 board is the most common type of epoxy boards.**
- PCBs are available in single- and multi-layer (e.g. 16-Layer) types.**
- Phenolic boards are single-layer.**
- Flexible boards are the thinnest PCB available and may be single or dual-layer.**
- Teflon boards are employed in high-frequency applications.**
- To make multi-layer boards, the boards then pressed on top of each other after the PCB layout is implemented (the Teflon-Epoxy board is also fabricated by this method).**
- Single-layer board has copper patterning only on one side.**
- Dual-layer board has copper patterning on both sides.**
- Teflon-Epoxy boards may have 2-4 layers.**
- Teflon boards may have 2-4 layers.**

- Low-frequency (FR4) boards are often recommended for industrial or military applications, while phenolic boards have commercial usage.
- Flexible boards are used in applications where the PCB is required to have high flexibility.
- Flexible boards are most commonly used in cell phones, computers, and flexible devices.

- Some of the common terms used regarding PCBs are as follows:

**** Silkscreen:** The names of the components printed on the board. This may be done in various colors.

**** Solder Mask:** A paint (usually green) used to cover all the surface area (except for solder points) to prevent connections and the oxidation of the copper.

**** Hot-air:** A reinforcement system for the solder mask to keep it from shrinking and being damaged when heated.

**** Plating:** The tin, tin-lead, or gold coating on the points that is not solder-masked. **** V-CUT:** A deep half-cut that is applied to the point where the board is connected to the panel for helping it to be detached easily from the panel.

**** Metalized:** In two (or more)-layer boards, the holes between the layers are connected using a metal to connect the top and the bottom of the boards. This method of connection is known as the metalized connection.

- The thickness of copper on the board is usually 35, 70, or 105 μm . The 105 μm thickness is used for high-current applications.

- The raw board becomes a PCB after etching, printing, and cutting.

-

- ER is a very important parameter regarding Teflon boards and distinguishes the application of each PCB.

- Common Teflon board thicknesses are 15, 31, or 62 mil (mil means milli-inch).

- Raw boards must not be exposed to air otherwise the copper is oxidized rendering the board useless. Important Parameters:

For low-frequency applications, FR4 or phenolic are common

choices. Teflon Boards: OZ value, thickness, dimensions, ER.

Related Pictures:



Some manufacturers:

Phenolic and Epoxy: Isola, Taiwan-Leader, KB

Teflon: Rogers, Taconic

Markings

Printed raw boards often have full markings.

Function: The contacts of these components may be opened and closed by stimulating the coil. Application: Relays are used where it is required to mechanically make or break a connection. Main

Specifications:

- Relays may come with a plastic (clear or opaque) or metal package.

- Relays are available in PCB- and panel-mount models.

- Relay coils are made for 110, 220 VAC, or 3 ~ 400VDC voltages.

- The most common DC voltages are: 5V, 6V, 9V, 12V, 24VDC

- Various models of relay contacts are available with the most common structures being: Normally Open (N.O): With applying voltage to coil, contact will close

Normally Close (N.C): With applying voltage to coil, contact will open

-

- Relays have at least one shared (common) terminal and a NO or NC terminal.

- The structure above is fabricated in the following configurations:

SP - NC SPST: Single Pole Single-Throw

SP-NO

(SPST is often the same as SP-NO)

SPDT: Single pole Double- Throw

Means one pole has a common terminal, an open contact and a closed contact (with respect to the common terminal).

DPDT: Double Pole Double Through

- Relays with metal (shielded) packages are often used for RF or military applications.
- Some relays have latches that maintain the contact position after the applied voltage is removed.

The contact position is maintained unless the coil is stimulated.

The contact position is maintained unless the coil is stimulated.

Latching relays with a single coil are set when a voltage is applied in a direction and reset when the polarity of the voltage is changed. the polarity of the voltage is changed.

Latching relays come with two coils, one for setting and another for resetting.

- Latching relays are often used in applications where sufficient continuous current is not available.

For example: In battery powered devices (where we need battery consumption to be very low).

- The following symbols may be printed near the coil in some relays:

+

S R

- +

These letters show the setting and resetting directions, implying the relay is definitely associated with a latch.

- The coil of some DC relays is directional so the two ends must be connected to the right poles.
- Manufacturers often provide the frequency-response and loss diagrams for RF relays.
- Military-grade relays often have an internationally-recognized code similar to M39016/XXX.
- Military-grade relays may also come in cylindrical and metal models.
- Solid-State and Mosfet relays have semiconductor contacts.
- Solid-state relays often incorporate Phototriac or Photocoupler isolators for their primary and secondary (input and output) contacts.
- The operating voltage of the contacts is often between 250 and 500 V. however, some relays that are used in matching circuits may withstand voltages of up to 10 kV.
- Electrical relays are often mounted on special sockets.

- Generally speaking, there are three types of relay terminals: 1) PCB terminals, 2) Solderable terminal, 3) Screw terminal (the wire can be twisted around it and the connection can be opened).
- In terms of sealing, there are two types of relays:
 - 1- Flux protection that is impermeable to soldering flux.
 - 2- Fully-Sealed.
- Two operating lifetimes are often attributed to relays: 1) Electrical, 2) Mechanical (between contacts). The mechanical lifetime is often 10~500 times more than the electrical lifespan of the relay. For example: The electrical lifetime of a coil in a relay is 50,000 times while its mechanical lifetime is 5,000,000 times.
- The electrical lifetime shows the durability of the coil against the number of times it operates.
- In cases where contact loss is not important, normal relays may be used for DC~1GHz applications.
- For relays with metal packages, the manufacturers often make an insulator for the bottom of the relay and recommend that the package does not contact the PCB.
- The voltage that initiates the relay coil is not exactly the nominal relay voltage and many relays operate at 70%-120% of the nominal voltage of the coil (or what is specified in the catalog).
- Some solid-state relays have an integrated zero-cross detector circuit, some have an indicator, some are associated with a snubber, and some incorporate a resistor at the input. Moreover, some models require heat-sinks.
- Generally, relays are sealed; however, some models are not and this would be specified in the catalog.
- The number of relay terminals is often as follows (two terminals are dedicated to the coil). However, in case the relay integrates two coils for latching, the number of terminals must be added with two.
 - SPST ==> 4
 - SPDT ==> 5
 - DPST ==> 6
 - DPDT ==> 8
 - 3PST ==> 8
 - 3PDT ==> 11
 - 4PST ==> 10
 - 4PDT ==> 14

- Sometimes, relays integrate combination contact (for example DPDT + SPST) that operates independently.

- The operating mechanism of relay coils (coil) is presented in the next page with respect to the applied voltage that is mentioned in the catalog:

Important Parameters

Normal relays: The operating voltage of the coil, contact position, the number of terminals, dimensions, whether incorporating RF, latching or normal, terminal type, directional or nondirectional coil, maximum contact voltage and current, package material, the corresponding military standard group (for military-grade relays).

Solid-state relays: Isolation method, zero-cross detector circuits, the nominal input voltage, the allowable output current, the allowable output voltage.

Mosfet relays: Contact position, load voltage, the number of terminals.

The maximum current or voltage of the coil

The nominal voltage or current of the coil

In this region, the relay must operate

In this region, the relay must be maintained in operation

Functional position The maximum pickup point

Max. dropout point

**The relay might
operate in this region**

Unknown

Function The relay might turn off in this region

minimum pickup point

minimum dropout point

**The relay
must not
operate in this**

region

Off

Position Relay must be turned off in this region

**Increase
voltage or
current of Decrease voltage**

coil Operating mechanism of relay coil or current of coil

 **Normal Relay**

 **Panel mount Relay**



Reed Relay



Some manufacturers:

Military-grade: CII (TYCO), Nova Hi-G, Teledyne

Normal, power: Omron, Nais, OEG, Finder

Mosfet, Solid-State: National or Matsushita, Omron

High-Voltage: Kilovac, Jennings, Crydom

Markings: The model, the name of the manufacturer, the rated current, the maximum allowable voltage, the voltage of the coil, terminal connection mechanism, and the positive and negative directions are often imprinted on relays. However, some of this information is sometimes omitted. Sensors are generally classified into the following groups:

- 1. Accelerometers**
- 2. Current Transducer**
- 3. Displacement Sensor**
- 4. Encoder: Absolute, Incremental**
- 5. Float Switch**
- 6. Flow Transducer, Sensor, and Switch**
- 7. Humidity Sensor**
- 8. Temperature sensor**
- 9. Load Cell**

- 10. Magnetic Sensor**
- 11. Mass Airflow Sensor**
- 12. Motion Sensor**
- 13. Optical sensor**
- 14. Pressure Sensor and SW., Force sensor**
- 15. Proximity SW.**
- 16. Tilt Sensor**
- 17. Ultrasonic Transducer**
- 18. Gas flow sensor/Gas detector/Smoke detector**

**** Generally speaking, given the various parameters and applications of sensors, the best way to select the right type of sensor is to consult the manufacturer's catalog after choosing the class. However, each class of sensors is briefly discussed here along with their corresponding images and manufacturers.**

There are two types of accelerometers:

- 1. Piezoelectric Accelerometers: A piezoelectric crystal generates oscillations with the vibration of the object it is attached to.**
- 2. Piezoresistive Accelerometer: A vibrating object is attached to an arm which generates a signal when tilted by the g-force.**

Related Pictures:

 **Acceleration**

 **Shock**



Vibration

Manufacturers: Monitran, Murata

These sensors are available in three types:

A. Current Transformer: The charge passing a current-carrying wire which runs through a hole in a transformer induces changes in the magnetic field of the transformer, resulting in voltage variations in the transformer output.

Related Pictures:



Some manufacturers: Thousands hundred, LEM

B. Hall-Effect Sensor: The passage of charges in the proximity of the sensor results in a voltage at the two ends of the sensor. Related

Pictures:



Some manufacturers: Honeywell, LEM

C. In-Line Current Sensor: This sensor is a current conductor. The circuit layout is printed and fixed, and the sensor is mounted on a PCB. This sensor is also known as in-line PCB pinout.

 **Manufacturer:** 

LEM

Application: Mold making and injection machines, meat packaging machines, woodcutters, precision cranes, robots, weighing scales, drills.

Specifications: Measures displacements of up to 1.5 m.

Related Pictures:



Some manufacturers: Monitran, Vishay

- These sensors transform the motion of the shaft or the rotating body into digital codes and are available in different types, including rotary, optical, Hall-effect, absolute and incremental. Related Pictures:

 **Optical**

Hall-Effect

 **Rotary**

Absolute

 **Incremental**

Some manufacturers: Hengstler, Bourns, HP, Grayhill, Spectrol

They are built in both horizontal and vertical models and must be selected based on the application. Related Pictures:

 **Some manufacturers: Crydom, Assemtech, GTI**

They identify the flow of liquids. Liquid mass flow sensors measure the amount of the passing liquid. Related Pictures:

 **Flow sensor**

 **Liquid flow switch**



Liquid mass sensor

Some manufacturers: Crydom, GTI, UCC

These sensors are available in capacitive and resistive types. Capacitive humidity sensors offer a wider range of measurement.

Related Pictures:



Some manufacturers: Thermometrics, Honeywell

There are five classes of temperature sensors:

. Probe

Thermocouple Cable

Temperature Sensors Connector

Platinum Resistance (PT 100)

Thermal Switch

Thermostat

PTC & NTC (Thermistor)

22-8-1 Thermocouple

Typically, there are three types of thermocouples:

Cable: A wire with sensors on the two ends.

 **Connector: A connector with an embedded sensor that is attached to a device or a thermometer.**

 **Probe: A metal rod encompassing a sensor.**



Thermocouple models are indicated by letters that will be readily discussed:

Letter Thermocouple Structure Indicators

T Copper/Copper-Nickel

J Iron/Copper-Nickel

K Nickel-Chrome/Nickel-Aluminum N Nickel- Chrome-Silicon/Nickel-

**Silicon S Platinum-10% Radium/Platinum R Platinum-13%
Radium/Platinum**

Some manufacturers: Labfacility

Temperature Range (°C) "-150 ~ +350" 0 ~ +700

0 ~ +1200

0 ~ +1250

0 ~ +1500

0 ~ +1600

22-8-2 Platinum Resistance (PT-100)

This is a precision temperature sensor that is available in probe and cylindrical models and can measure temperatures in the range -200 to 800 °C.

Related Pictures:



22-8-3 Thermal Switch

- These components are available in panel-mount, wired, and TO-220 types and are typically used at temperatures below 250 °C. Mostly, thermal switches are mounted on heat sinks to control the temperature of the heat sink or the components installed on it.

- Thermal switches are available in normal-open and normal-close models.

- Thermal switches are bimetallic.

- The cutoff and trigger temperatures are not the same in thermal switches (for example, in a 90 °C model, the cutoff temperature may be 90 °C while the trigger temperature is 60 °C).

- Some models are equipped with manual reset buttons but generally, they can be reset automatically. Related Pictures:



To-220

Auto reset

 **Some manufacturers: AIRPAX, MICROTHERM Insulated**



Manual reset

22-8-4 Thermostat

Thermostats are a class of sensors similar to temperature switches, only different in that their cutoff temperature is tolerable and they are mainly used in refrigerators, room temperature sensors (for commanding the fan coil unit), etc. These components are often a combination of a sensor and electronic and mechanical components.

Images:



22-8-5 NTC and PTC Thermistors

Refer to Section 1-6 Resistors.

These sensors are mainly used in weighbridges and digital weighing scales. Images:



Manufacturers: TEDEA

These sensors operate based on the Hall Effect and are mainly employed to detect when a body approaches them. Examples of application include cordless telephones. Images:



Manufacturers: Honeywell

These sensors measure the airflow or the mass airflow and are used in air-conditioning devices, anesthetic gas or air controllers, gas measurement equipment, etc.

Images:

 **Mass air-flow sensor**

Manufacturers: Air flow sensor Honeywell

Motion detection, engine start, security systems, etc.
Images:



Manufacturers: Assemtech
Photo Switch Optical Sensors

Slotted
Optical level SW. Reflective

Infra-Red and

There are three types of photoswitches: 1. Slotted: when turned on, generates output signals as matter passes through their slot. These switches are very useful in identifying the number of spins, rotation, etc. Images:



2. Reflective: An optical transmitter and a receiver assembled in one package. One component transmits light that is collected by the receiver if it is reflected from a barrier. Images:



3. Optical Level Switch

It is often placed above the surface of a liquid and identifies whether it reaches that level. Images:

 **Manufacturers** 
Honeywell

22-13-2 IR Diodes

Often, composed of one diode as the transmitter and another as the receiver (detector). IR-diodes are mainly used to identify moving objects.

 IR emitter



IR SMD

Some manufacturers: MARL, Agilent, Infineon

This sensor generates an output signal when pressure is applied (impact). A force sensor specifies the applied force.

Images:

 **Pressure sensor**

Sensor , Pressure sw.



Force sensor Some manufacturers: Honeywell

This sensor detects when an object approaches it and is extensively used in continuous mechanized production lines, and level or motion In terms of operating mechanism, magnetic, capacitive, inductive, ultrasonic, and optical proximity sensors are available.

 **Magnetic**

 **Inductive**  **Capacitive**

 **Ultrasonic**



Optical Some manufacturers:

The names of the manufacturers are shown inside parentheses:

Magnetic (Assemtech, GTI)

Capacitive (Omron)

Inductive (Pepperl + Fuchs, Omron, Proxistor)

Ultrasonic (Assemtech, Pepperl + Fuchs)

Optical (Sick, Datasensor, Omron)

This sensor is often composed of a sealed enclosure filled with mercury that connects the two terminals. The connection breaks when the

system is tilted.

Images:



Manufacturers: Assemtech

This sensor is often composed of an ultrasonic transmitter and a receiver. Ultrasonic sensors are often used in remote controls and security systems and motion sensors. Images:

 **Receiver (RX) Transmitter (TX) Manufacturers Prowave**
22-18 Gas Flow Sensor and Detector/Smoke Detector  **This sensor detects the flow or presence of smoke or gas. In practice, there is a specific sensor for each type of gas, such as methane, carbon dioxide, or carbon monoxide, or smoke.**

Images:

 **Gas flow sensor**



Gas sensor(detector)

Aspects Shared by all Switches

Switches are available in different groups, with the most important ones being: 1. Code SW.

2. DIL SW

3. Interlocking (Multi-pole)

4. Keyboard

5. Key Operated SW.

6. Microswitch

7. Push button

8. Reed SW.

9. Rocker

10. Rotary

11. Slide and Voltage selector

12. Tactile SW. (Tact SW.)

13. Toggle

14. Tilt SW. (Refer to section 22-16 Tilt Sensor)

15. Dome

Function: The switch is composed of at least two contacts with

selectable position. The application of each type of switch is discussed in the corresponding sub-class. Main Specifications:

- Each switch has one common terminal and at least one NO (Normally Open) or NC (Normally Close) terminal.

- Similar to relays, switches have defined contact configurations (the numbers on the right indicate the number of terminals):

SPST ==> Single Pole Single-Throw ==> 2

SPDT ==> Single Pole Double-Throw ==> 3

DPDT ==> Double Pole Double-Throw ==> 6

3PDT ==> 3 pole Double-Throw ==> 9

DPST ==> Double Pole Single-Throw ==> 4

4PDT ==> 4 pole Double-Throw ==> 12

- Switches may also be defined by these positions:

ON-OFF: In one position, the common terminal is not in contact with any other terminal while it is in connected to the contact in the next position.

ON-ON : In one position, the common terminal is connected to one of the terminals while it is connected to the other terminal in the next position.

ON-OFF-ON:

The common terminal is connected to one terminal - The common terminal is not connected to any terminals - The common terminal is connected to the other terminal

ON-MOM (Momentary)

ON-OFF-MOM

OFF-MOM

**** The MOM position is spring-operated and the common terminal is connected to the spring terminal when it is pressed down.**

- Often, the number of switch terminals shows their function. For example, a two-terminal switch is often ON-OFF or OFF-MOM.

- Three-terminal switches have an ON-OFF-MOM, ON-ON, or ON-OFF-ON function. However, rotary switches are defined in a different way meaning that by each rotation, the two adjacent terminals are either connected or separated.

- Some switches have an OFF position which is when the common

terminal is not connected to any other terminals.

- **Switches do not have MOM-MOM positions. Instead, they have these positions:**

MOM-OFF-MOM: This is for three-terminal switches.

MOM-ON-MOM: This is for four-terminal switches in which the left or right MOM provides a spring connection for the two terminals on the left or right. The ON position maintains the two middle terminals indefinitely connected.

- **The Shaft is the part of the switch that may be pressed by hand resulting in the switch function.**

- **Shafts are made in different lengths and from different materials (plastic, metal, etc.).**

- **The most general types of shafts:**

Circular (cylindrical)

Flatted

Two Flat Sides

Screw Drive

Two Flat Sides with Central Hole

Rectangular

- **Some switches are "waterproof"; this could imply the shaft is waterproof, the body is waterproof, or both the shaft and body are [fully] sealed.**

- **The switch package may be made of different materials (plastic, metal, etc.) and is available in different colors.**

- **Switch terminals are often either PCB-mount or solder lug (for attaching a wire). The second model is often used for special panel-mount switches.**

- **The switch shaft may be parallel or normal to the terminals.**

- **Generally, switches that incorporate a shaft come with a knob.**

- **Some switches feature Shorting and Non-shorting positions. Shorting is when the common switch terminal is moving from one contact to another the two contacts are short-circuited for a few moments.**

The non-shorting position is when the two contacts are never connected.

The shorting position is used when we do not want to lose connection or data while the non-shorting position is used when we require each contact to operate separately.

- There are a few general terms regarding switch contact:

Pole: The number of switch contact groups

Throw: The number of conduction positions, one or two

Way: The number of conduction ways, three or more

Momentary: The switch is set back to its normal state when the pressure is removed. **Open:** Off position, the contacts conduct no charge.

Close: On position, the contacts are conducting charge; there may be multiple on positions. **The mechanical life of the switch is:** The lifetime of the mechanical parts of the switch. **The electrical life of the switch is:** The lifetime of the electronic parts (the embedded PCB fiber)

The Main Classes of Switches

- This switch is a rotary switch in which the terminals function and connect based on predefined digital BCD, Binary, Gray, and other types

- These switches may be constructed of multiple independent levels that share one shaft.

- These switches may feature an OFF position.

- These switches may also feature a MOM position (at the end of the rotation to one direction to the right or left)

- Some code switches do not have a shaft or are equipped with a plastic shaft similar to potentiometers.

Important Parameters: The number of levels (banks), the type of code, the length and the shape of the shaft, straight or right-angle, the number of terminals, whether featuring an OFF position, the rated voltage, the maximum allowable current, the number of switch positions, the angle of throw.

Related Pictures:



Some manufacturers: EBE, Knitter Switch, Grayhill

Markings Often, only the manufacturer part number is imprinted on the package.

23-2 DIP (Dual In-line Parallel) Switch

- DIP switches are a group of On-OFF miniature switches with SPST function.
 - Their shapes and dimensions are similar to an IC and the pitch of their two side terminals is often 2.54 mm.
 - These switches are made in top-adjust and side-adjust models. The side-adjust model is less common though.
 - Typically, there are two terminals for each switch.
 - DIP switches may incorporate a toggle, protruded, flat, or piano-key shaft.
 - Sometimes, these switches are made with a rotary configuration.
- Important Parameters** The number of switches, shaft style, package and shaft color.

Related Pictures:

Piano Piano-SMD

Normal



TRI-State

Some manufacturers: EBE, Knitter, Crayhill, etc.

Markings: Often, only the switch numbers and the ON position are imprinted on the body.

- The shaft is always at side (right-angle) position with respect to the terminal.
- These components often have two MOM or Latch positions.
- All SPDT, DPST, DPDT, and 4PDT contact configurations are available (in addition to others). **Important Parameters:** Contact configuration, the total number of switches, the number of latch switches, the number of MOM switches.

Related Pictures:



Some manufacturers: Alps

Markings: Often, only the manufacturer part number is imprinted on the component while sometimes there are no markings at all.

- Keyboards are a group of push-buttons that have flexible panels beneath them and are built in groups and are not separable.
- Keyboards are available in various 4×5, 4×4, 4×3
- Keyboard labeling may vary depending on customer demand.
- Keyboards also come in waterproof models.
- Some keyboards feature flat keys while other has protruded keys.
- Keyboards come in various colors.

Important Parameters: The number of keys in the length and in the width, the dimensions of the keyboard, key labeling.

Related Pictures:



Some manufacturers: Grayhill, etc.

Markings: Often, the most important marking is the key labeling.

- These switches offer a combination of electronic and mechanical mechanisms and feature a key that is used for changing the position. The key may be removed, thus preventing position switching.
- These switches are used in places in need of a high level of security.
- Sometimes, the key cannot be removed in all positions. For example, in some models, the key may only be removed in OFF position.
- The number of positions may vary from 2 to 6.
- The switch package is often made of either plastic or metal.
- The switch may be flat, recessed, or raised in the latched position.
- These switches are also available in waterproof models.
- Key-operated switches feature a maximum allowable current of 0.1~10 A.
- These switches are made for AC (mains) and DC voltages.

Important Parameters The number of positions, the casing material, configuration in the latched position, current, voltage.

Related Pictures:



Some manufacturers: EBE, Grayhill, etc.

Markings Often with no particular, standard markings.

Microswitches are a diverse group of switches and often have small dimensions. These components usually operate by applying pressure to a small actuator on the case. Microswitches do not feature a latching position, meaning that the contacts are connected when pressure is applied and opened when pressure is removed (only momentary).

- Microswitches may have pin plunger, straight lever, or roller lever actuators.**

- Microswitches are often ON-ON=SPDT (one NO and one NC) but sometimes SPST, DPDT, DPST, and 3PST models are also produced. Three types of terminal configurations are available, namely PCB-mount pin, wire-mount terminal, and wire instead of pin.**

- There are many color choices for the casing color but black is the most common.**

- Microswitch terminals are either placed on the sides or at the bottom with respect to the actuator.**

- Microswitches come in a variety of allowable currents from a few mA up to 20 A and allowable voltages of up to 250 VAC.**

- Some models of microswitches are sealed.**

- The mechanical lifetime of the contacts in different models can be 10,000 to 10,000,000 connection cycles while the electrical life may be 10,000 to 100,000,000 ON/OFF cycles.**

- Switches with gold contacts often have a similar mechanical lifetime but their electrical lifetime can be many times longer than contacts made of silver or other alloys.**

- The maximum allowable current of the switch with silver contacts is often more than gold contacts. Important Parameters:**

Contact configuration, terminal configuration, actuator configuration, dimensions, the orientation of the terminals with respect to the actuator, voltage, current.

Related Pictures:



Some manufacturers: Omron, Cherry, Augat

Markings: The name of the manufacturer, model, NC, NO, and C terminals, and sometimes the maximum allowable voltage and current.

Microswitch actuator configurations:



Push-button switches are often available in three types:

SP-NC (Momentary): In the normal state, its two terminals are connected and applying pressure on the actuator opens them up.

SP-NO (Momentary): The two terminals are separate in the normal state and applying pressure on the actuator closes them.

SPST: With one push on the actuator the terminals are connected and with another push, they are separated (in fact, this is a latching switch).

- Push-button switches are often panel-mount; however, they are available in PCB models too.
- The actuator often has a square or circular shape.
- The other terminal configurations include DPST, SPDT, 3pDT, 3PST, and DPDT.
- The switch actuator and the casing are available in different colors.
- Sometimes, the terminal is right-angle with respect to the actuator.
- Some of these switches have an integrated LED in them (beneath the actuator) that turns on during operation.
- The allowable current can be a few mA to around 10 A while the allowable voltage may be 12 VDC to 250 VAC.
- The terminals are often pin-type in PCB models and screw-type or terminal for attaching a wire. Sometimes, the wire itself acts as the terminal.
- The casing of these switches is often made of metal or plastic.
- Based on the application, these switches may be found with actuators and casings of various dimensions.
- Some manufacturers: provide separate caps for the various applications of the switch.
- Some models are sealed and sometimes a sealing cap is offered separately.

- Some manufacturers: install holders and fasteners (brackets) on their switches.

- Some standard accessories include: Normal cap, sealing cap, cover.

Important Parameters The actuator and casing shape, function, actuator color, the number of terminals, the orientation of the terminal with respect to the actuator, integrated lamp, rated current and voltage, the diameter of the threaded section to be mounted on the panel.

Related Pictures:



Some manufacturers: Knitter, Apem, etc.

Markings: Given its small size, often only the manufacturer name and part number are imprinted on this component.

- In these switches, the contacts are closed when a magnet (or magnetic field) approaches them

(this holds for the SPST model, however, SPDT models are also available).

- Applications for this type of switch include security circuits (for example, for checking whether the doors are closed).

- These switches are packaged in a fragile glass envelope.

- Reed switches are available in various lengths and diameters.

- The maximum allowable current may reach many amperes in this type of switch. **Important Parameters** Contact position, envelope length, envelope diameter, maximum allowable current and voltage.

Related Pictures:



Some manufacturers: Hamlin, Assemtech

Markings: Often without markings.

- The actuator in these switches features a wide surface.

- The name of this switch is derived from the motion of the actuator (rocking motion).

- The switch function may be ON-ON, ON-OFF, ON-ON (Momentary), ON-OFF-ON, etc.

- The contact configurations may be 4pDT, DPDT, DPST, SPDT, SPST, etc.
- The casing of this type of switch is available in different colors.
- In some models, the actuator features a distinguished colored section that is only visible in ON state.
- In some models, the key integrates a lamp that turns on when the switch is ON.
- In some models, the actuator is marked with 0 and 1 to determine the operation and the installation.
- Rocker switches are often panel-mount and have terminals.

Important Parameters The operation, contact position, actuator color in ON state, integrated lamp, the number of terminals, the maximum allowable current and voltage.

Related Pictures:



Some manufacturers: Arcolectric, Knitter switch

Markings The manufacturer name, model, and the allowable voltage and current.

- Rotary switches are a diverse group of switches that feature rotating shafts.
- The casing in these switches may be made of plastic or metal.
- Some rotary switches do not have a shaft and the actuator must be rotated by a screwdriver.
- The shafts are available in various models including circular, flat, two flat sides, and screw-drive.
- These switches may have multiple banks.
- The number of switch positions is determined by the number of steps:
The number of positions = The number of steps + 1
- Each position connects two adjacent or common terminals to a non-common terminal
- Each bank may integrate multiple poles. Poles are parallel, similar connections in each bank.
- Selectors may be panel-mount or PCB-mount.
- The terminals may be right-angle with respect to the shaft.

- Some selectors have an OFF position in which the common terminal is not connected to any

terminal.

- The number of positions can be reduced in some selectors. This adjustment is carried out using a stop pin.
- Selectors are available with various casings. In some models, the inside of the bank is not visible.
- Three types of waterproof rotary switches are available: Switches with sealed casings, those with sealed shafts, and those with both sealed shaft and casing.
- During rotation, the terminals may be connected in two ways:

Shorting: The common terminal and the previous terminal are in contact until the common terminal is fully connected to the new terminal.

Non-Shorting: The common terminal and the previous terminal are disconnected immediately when the shaft starts to rotate.

- In some models, the selector knob is mounted on the shaft.
- The angle to which the shaft is rotated from one position to the next is also important and is often in the range $1\sim90^\circ$. However, common steps are 15, 30, or 45° .

Important Parameters:

The number of banks, the number of poles, and the positions in each bank, installation (PCB- or panel-mount), the configuration of the terminals with respect to the shaft, the maximum allowable voltage and current, whether featuring an OFF position.



Related Pictures:

Some manufacturers: EBE, Knitter, Cole, Grayhill

Markings: Often, only the manufacturer name and the model are imprinted on the body.

- These switches connect two adjacent terminals in each step.
- The shaft may be right-angle with respect to the terminal.

- Contacts feature various configurations such as SPST, DPST, SPDT, etc.
- The shaft and the casing are available in various colors.
- Some models feature a cover on top.
- The shaft may be made of plastic or metal.
- The switch can be either PCB-mount or panel-mount.
- Some slide switch models, known as Voltage-Selector switches, do not have a shaft and their actuator is adjusted using a screw-driver. Two voltages are indicated on the actuator (for example, 110 and 220). - This switch is only available with an SPDT configuration and is often used in electronic devices for select an input for the operating voltage. Moreover, slide switches are often panel-mount and the maximum allowable current is one of their most important parameters. Important Parameters: The maximum allowable current, contact configuration, the number of terminals, whether featuring a cover, the orientation of the shaft with respect to the terminals, shaft material, installation.

Related Pictures:



Slide sw. Some manufacturers: Knitter, APEM

Markings: The manufacturer name, but often without markings.

- Tactile switches are a group of pushbutton switches but do not have a locking mechanism, and are treated as a separate group given their diversity.
- These switches often have four terminals and are square; however, dual-terminal, rectangular models are also offered by some manufacturers:
- Their actuators are often either flat circular or protruded square (rectangular or cross-shaped models are also available).
- The height of the actuator may vary from 1~10 mm.
- The casing may have a grounding terminal or no terminals at all.
- The force exerted on the actuator for the switch to work varies from 1 to 5 N in different models.
- These switches do not have a locked state and the terminals are

connected when pressure is applied and disconnected when the pressure is removed.

- In these switches, and in the four-terminal models, the terminals are connected in pairs.
- Typically, these switches are available in 6×6 and 12×12 mm sizes.
- Sealed models are also available and SMD models have become common.
- These switches feature a low maximum allowable current (in the order of few mA) and are often used in DC applications.
- The mechanical lifetime of this type of switch may vary from a few hundred thousand to tens of millions times of actuation which is always specified in the catalog.
- Right-angle models are also available (the orientation of the actuator with respect to the mounting terminal).

Important Parameters: The number of terminals, the shape and the color of the actuator, switch dimensions, actuator height, the force required to function, the orientation of the terminals with respect to the actuator.

 Tact switch



SMD side actuated :



Some manufacturers: ITT, ALPS, Omron, Knitter, Bourns, EBE

Markings: Often, either without markings or only bearing the name of the manufacturer.

- Toggle switches feature a lever that has a 30° range of motion at maximum.
- The shaft often has two or three positions, making up the following possibilities: ON ON

ON OFF ON

ON MOM (Momentary)

Mom OFF Mom
Mom OFF ON
ON ON ON
ON OFF
Mom on Mom

- The contact configuration is often SPST, SPDT, DPST, DPDT, 3PST, 3PDT, 4PST, or 4PDT, implying that the number of positions may be one or two while the number of poles may vary from one to six.
- The shaft may be normal (cylindrical) or flat and may feature a latching mechanism.
- Latching shafts require to be pulled up before being moved when it is needed to displace them, in fact, normally they cannot be displaced by pressure as if they are locked.
- The shaft is often made of plastic or metal.
- The shaft may be right-angle with respect to the terminal.
- Switches come with various casing colors.
- Terminals are often in the form of pins, wire-wrap pins, and panel-mount terminals.
- The component is often either panel- or PCB-mount.
- Different voltages and currents are available for this type of switches.
- Other particular models include: Waterproof, Anti-ESD (protection against high voltage, meaning the resistance of the shaft with respect to the terminal which is available for voltages of many kV).
- Some general accessories of these switches are: Normal cap, sealing cap, bracket.
- The electrical lifetime of toggle switches is often around 50,000 operations while the mechanical lifetime is around 100,000.

Important Parameters

Operation mechanism, contact configuration, the type of the shaft, shaft material, installation, the orientation of the terminal with respect to the shaft, the maximum allowable voltage, the maximum allowable current.



Some manufacturers: Knitter, C&K, APEM

Markings Often, the name of the manufacturer and the switch model are imprinted on the switches and sometimes, the maximum allowable current and voltage.

- Dome switches are keys that are placed below keyboards and function similar to tact switches.
- These switches do not require soldering and the manufacturers arrange them on a flexible sheet in the layout demanded by the customer.
- These components are incorporated in many devices such as cell phones, and digital camera
- Dome switches have a service life of around 1,000,000 operations.
- These switches are never provided to the consumer without protection.

Parameters:

Diameter, the number of switches, arrangement.

Related Pictures:



Some manufacturers: Omron

Markings Without markings

(Only displays are intended to be covered here)

Function:

Meters display the numerical value of the applied current or voltage or the sensed thermal energy. **Application:**

As a display mounted on the panel, meters show device parameters.

Main Specifications:

- Test equipment may be digital or analog.
- The analog models are available in edgewise (with the hand moving along the length) and normal types (with the hand rotating in the middle).
- These components are available for usage in a variety of devices including: Ammeter, voltmeter, micro-ammeter, temperature display.

Important Parameters:

Application, dimensions, accuracy.

Related Pictures:

Edgewise



Panel meter (moving coil)

Some manufacturers: Triplet, Yokogawa

Markings

Often the name of the manufacturer, the product number, and the operation range are imprinted on the component.

Components with multiple semiconductor elements sandwiched between two ceramic plates. Peltier devices feature a hot and a cold side. These devices are available in round, square, and rectangular forms.

Application:

Electronic cooling systems, portable thermoelectric coolers, etc.

Important Parameters:

Images:



Manufacturers

Supercool, Eureka

26-1 Functional Testing

Testing a Fixed Resistor

Two types of multimeters can be used for testing purposes:

Testing using a digital multimeter: Set the multimeter to the resistance mode, and contact the two probes to control the multimeter wires and the device error. Then, place the probes on the two sides of the resistor and read the resistance from the device. If the reading is close to the

resistor value indicated by the color codes (taking the device error into account) the resistor is good.

Digital Multimeter

Analog Multimeter



Testing using an analog multimeter: Set the multimeter to the resistance range mode in this method too. The resistance range depends on the expected resistor value. If the resistor is 10k, the multimeter must be set to the Rx10k range. Similar to the previous method, the reading must be close to the expected resistor value (taking the error into account).

Testing Variable Resistors

Trimmer and Potentiometer: To test a potentiometer using an analog multimeter: First, set the device to the correct range, and test the middle potentiometer terminal with respect to the other two terminals. Naturally, the reading depends on where the volume is set but the sum of the two readings from the two terminals on the sides shows the overall potentiometer resistance.

Now, to verify the potentiometer functions properly, the resistance with respect to one of the side terminals can be checked while turning the knob. Variations must be observed in resistance, but the variations must be uniform and without interruption, otherwise, the potentiometer is defective. The same holds for trimmers.

Testing variable resistors that operate through physical changes:

Testing an LDR Resistor This type of resistor responds to changes in lighting. Therefore, the best way to test it is to read the resistance from a multimeter that is connected to its two terminals and is set to the Rx1k range under light and compare it to the reading under the shadow. A response to change in the lighting proves the resistor to be good.

Testing a VDR Resistor The value of VDR resistors decreases with increasing voltage. Accordingly, they are used in applications where the voltage is needed to be fixed (such as in Zener diodes). However, given the high voltages that are applied to this component, they cannot be

tested using an ohmmeter and must be tested in-circuit, knowing the local voltage.

Testing a PTC Resistor: The value of a PTC resistor increases with the temperature. Accordingly, this component can be tested by monitoring the changes in its resistance (using a multimeter) when it is heated with a soldering iron or a blow drier, its resistance increase. The reverse also applies. **Testing an NTC Resistor:** This resistor is the opposite of PTC.

Testing Capacitors using a Multimeter:

It is not easy to test capacitors below 10 nF using a multimeter and a capacitance meter (or LCR meter) is required for the job.

Testing capacitors with values ranging from 10 nF to 1 F: To test these capacitors, set the multimeter to the Rx10 range. If the capacitor was previously discharged, the 9 V battery in the multimeter charges it when the device is connected to the capacitor terminals. While charging, the multimeter hands show the instantaneous circuit resistance as current flows. The maximum value indicated by the hand must be remembered as it is deflected in proportion with the capacitance.

In this method, the capacitor is good if it does not leak and the resistance is infinite after being fully charged. In case of charge leakage, the hand shows a resistance indicating the capacitor leakage. If the capacitor is damaged, no response is observed and the hand is not deflected.

Testing capacitors with values ranging from 1 F to 10 F: Before forming a judgment, it must be kept in mind that these capacitors are electrolytic, therefore, their capacitance may change. This test only shows whether the capacitor has short-circuited or is open and the change in the capacitance must be tested using a capacitance meter. However, this does not mean that an electrician does not need to learn this method.

For this test, set the multimeter to the Rx1k range. Then, charge and discharge the capacitor considering the poles of the multimeter battery (the black wire is the positive pole and the red wire is the negative pole).

Testing capacitors above 10 F: In order to test this type of capacitor, the

multimeter must be set to the Rx100 range: When charging and discharging capacitors it is important to note the poles, some leakage is acceptable. Therefore, after the capacitor is charged the hand shows a high resistance. If the capacitor does not move the hand, it means that it is open and if it indicates zero, it implies that the capacitor has short-circuited, and if the capacitor gives a small resistance reading, the capacitor has deteriorated.

Testing Various Diodes

Testing Diodes using a Multimeter First, it must be kept in mind that testing electronic components in-circuit and out of the circuit are different. Testing normal diodes: Normal diodes are made of silicone and allow various currents for different applications. The simplest type of diode is the 1N4148 diode that is small similar to low-power Zener diodes and has a glass envelope. Other examples include 1N4001 to 1N4007 series that are most applied in low-frequency rectifying such as in adapters. After a brief introduction to normal diodes, their testing method is discussed: The component is first tested out of the circuit. Place the multimeter probes on the diode terminals in forward bias to test the current. Here, the red probe must be connected to the cathode and the black probe to the anode of the diode. The cathode is marked by a curved line on the diode casing. In this case, current flows through the diode from the multimeter battery and the resistance can be read from the multimeter (generally between 20 and 30

well enough.

Testing in reverse bias: In this case, the red probe of the multimeter must be placed on the anode while the black probe is to be placed on the cathode. However, given that the multimeter must be set to the Rx10k mode, one must be careful not to touch the multimeter terminals since it is set to measure large resistance values so even the smallest charge leakage is not acceptable and the multimeter should not show any deflection.

Testing a Zener Diode Testing a Zener Diode

the multimeter. In reverse bias, the multimeter must be set to the Rx1k mode and leakage is not acceptable. However, in order to fully control

the Zener diode, it must be placed in the circuit at a voltage above the breakdown voltage to measure the breakdown voltage to ensure it is correct. Testing an LED: Closed circuits incorporating an LED must include a current limiting resistor. LEDs consume 10-20 A electricity and a current-limiting resistor must be integrated into the circuit accordingly. The voltage required by the LED depends on its color and may vary from 1.7 to 2.2 V. This voltage is obtained very easily; one should simply measure the voltage at the two ends of the LED when it is integrated into the circuit (with a current-limiting resistor in series). If the LED is required to be tested in forward bias, the applied voltage must be above 1.5 V. It must be mentioned that most multimeters (such as the Hioki 3007) use a 1.5 V battery for testing the resistance in Rx1, Rx100, and Rx1k modes, which cannot turn an LED on since, as mentioned earlier, a minimum 1.7 V voltage is required to overcome the potential barrier. Therefore, even in forward bias, the Rx10k mode that is powered by a 9 V battery must be used to test LEDs. therefore: mode that is powered by a 9 V battery must be used to test LEDs. therefore:

mode.

Reverse bias: Multimeter must be set to the same mode and no leakage is acceptable. Testing an infra-red transmitter LED: Forward bias: The multimeter must show a resistance of 20-30

Reverse bias: Multimeter must be set in the Rx10k mode and no leakage is acceptable. Diode: To fabricate a diode, an n-type semiconductor is coupled with a p-type, which leads to an interesting phenomenon at the interface. This configuration rectifies the current in the diode. As we know it, a depletion region (or a potential barrier) is formed at the interface between the two semiconductors that is similar to a battery with its positive pole in the n-type semiconductor and its negative pole in the p-type semiconductor.

The potential barrier can be overcome with a voltage of 0.6 to 0.7 V in forward bias from N to P and the diode allows current to pass.

Therefore, if the supplied voltage is below 0.7 V the potential barrier blocks the current. Naturally, when the voltage exceeds 0.7 V, the potential barrier is overcome but 0.7 V of the voltage is used for diode

bias and is subtracted from the supply.

Therefore, if the applied voltage is larger than 0.7 V, flows through the diode but it results in a 0.7 V drop in the voltage (for example, if a 3 V voltage is applied to the diode, only 2.3 V of it appears on the resistor). In reverse bias, diodes do not allow any current to pass as the potential barrier increases by the supplied voltage.

It is concluded that by using a digital multimeter, only the bias voltage of a forward-biased diode can be found. Thus, verifying that the diode is good.

Identifying Transistor Terminals This terminal is known as the base (B) terminal. If this terminal is identified using the red wire, it indicates that the transistor is of PNP type (or positive) while in case it is identified using the black terminal it is said that the transistor is of NPN type (or negative). Now that the B terminal and the type of transistor is determined, the multimeter is set to the Rx10k range to identify the other two terminals. The two terminals must be tested in both directions with respect to one another. In the direction that the multimeter shows current flowing, the terminal that identified the base is emitter (E) and naturally, the next terminal is the collector.

Testing Thyristors and Triacs

Given the fact that some thyristors and triacs require a high current for stimulating the gate, an ohmmeter cannot be always used to test triacs and thyristors. Instead, one should use the following method.

Pick a 9 V battery and connect its positive pole to the anode and its negative pole to a small 3 V lamp. Then, connect the other lamp terminal to the cathode. The lamp must be turned off at this point. Next, for a brief moment, connect the gate base to the anode using a wire. This should turn the lamp on (if the gate is negative, it should be connected to the cathode).

Then, detach the wire connecting the gate to the anode. The lamp must remain on even after the wire is detached.

Notice: In thyristors and triacs whose gates requires a small stimulation current, the red probe is to be placed on the cathode and the black one on the anode. In this case, the ohmmeter hand must

remain within the x1 range and should not move. Then, the anode is connected to the gate and the indicator must show a resistance and remain there if so, the component is good.

Testing an IC

ICs cannot

For example, there must be no resistance in either direction between the IC terminal that receives the maximum voltage (supply terminal) and the terminal that runs to the chassis (or to the metal IC casing)

Testing Vacuum Tubes

First off, no black or white dust must be visible on the inside of the glass envelope. Second, the two filament terminals must give a resistance reading (in a 7-pin lamp, pins 3 and 4 are the filament terminals, in an 8-pin lamp, pins 1 and 8, in a 9-pin lamp, pins 4 and 5, in a 10-pin lamp, pins 5 and 6, and in a 12-pin lamp pins 1 and 12 (or 6) are the filament terminals).

Testing Fuses In-Circuit

After setting the ohmmeter to the x1 range, place its probes on the two terminals, if the resistance was zero the fuse is good (it is best to test the fuse out of the circuit).

26-2 In-Circuit Testing

Testing a Resistor In-Circuit

With the device turned off, place the ohmmeter probes on the two ends of the resistor. If the value shown by the ohmmeter complies with the color indications on the resistor, it is good. However, one must bear in mind that testing resistors in-circuit is not accurate and at least one terminal is required to be removed from the circuit. The ohmmeter may be set to DC voltage with one probe placed on the chassis and the other on the sides of the resistor, if a voltage was read on one side while no voltage could be found on the other, the resistor is probably burnt (however, it is possible that the resistor value was high or one of its ends is connected to the chassis, in this case, one end of the resistor shows voltage while the other does not).

Testing a Capacitor In-Circuit

At least one terminal must be removed from the circuit before placing the ohmmeter probes on the two sides of the capacitor. In general, when working with an electrolytic capacitor, the ohmmeter indicator must deflect back and forth while in other capacitors, the indicator must not move at all if the capacitor is good.

Testing a Variable Resistor In-Circuit

Variable resistors cannot be tested in-circuit. The soldered terminals must be freed before placing the ohmmeter probes on them. If the indicator does not deflect, the resistor is good. Often, this is not an accurate way to test variable resistors. Instead, diagnosing problems with the device can easily lead to the conclusion that the variable resistor is defective. For example, the variable resistor is defective in a radio that emits a whistling sound or noise when the variable resistor is turned, fails to be tuned to a station at a particular position on the screen, mixes different stations, or can be tuned to only one station.

Testing Variable Resistors by Voltage

If the base voltage of the mixing transistor changes when adjusting the variable resistor, the variable resistor is good.

Leakage in Capacitors

Compared to other types of capacitors, electrolytic capacitors are damaged more easily and develop leakage current. This means that a small connection is made between the two metal capacitor plates through the dielectric. Determining exactly whether the capacitor has leakage current is only possible using a capacitance meter.

Which capacitors are most prone to leakage current?

Leakage current is common in audio devices or power-supply filter capacitors leading to disruptions in the sound. Another common example is in car stereos between preamp decks and in radios, where leakage current is quite common in electrolytic capacitors in the path to the loudspeakers, muffling the sound. In order to find the defective capacitor, first, the stereo is turned on, then, a new electrolytic capacitor is placed in parallel to the capacitors in the circuit one-by-one from behind the board. If the sound becomes clear again on a

capacitor, that is the defective one. Furthermore, in TVs, the leakage current is common in power-supply filter capacitors and the horizontal deck capacitors (boost capacitors) on the video output power supply.

What are the symptoms of a leaking capacitor?

Often, after the device has been turned on for a while, the capacitor becomes hot or swollen or the plastic piece at the bottom becomes stiff.

Testing Coils In-Circuit

After setting the ohmmeter to the x1 range, its probes are placed on the two sides of the coil. If it gave

Testing Ifs, coils, Chokes, and Transformers In-Circuit

Setting the ohmmeter to the x1 range and turning off the device, the primary and secondary terminals should not indicate zero to one another. In a transformer, none of the terminals should read zero with respect to the metal casing. In addition, the primary and secondary terminals must show a small resistance.

Testing a Diode In-Circuit

Set the ohmmeter to the x1 range and place its probes on the two sides of the diode. If the resistor value is the same from either direction (meaning that the indicator does not move or deflects to the same degree) the diode is burnt but if the reading was larger on one side, the diode is good.

Testing a Thyristor In-Circuit

The voltage between the anode and the cathode must be around 1 V, while the voltage between the gate and the cathode is to be around 0.7 V.

Testing a Transistor In-Circuit

Set the ohmmeter to the x1 range and turn the device off. Consider the base and emitter terminals and the base and collector terminals as two diodes, and do as instructed for testing diodes in-circuit (if the reading from the base and the emitter or collector terminals is similar in either direction the transistor is defective, but if the base terminal gives no readings in one direction or the reading was larger in one direction, the

transistor is good).

In FET transistors, the gate terminal (G) must be considered as the base terminal, the drain terminal as the collector, and the source instead of the emitter. Meanwhile, when working with a UJT transistor, consider the emitter terminal as the base, the B2 terminal as the collector, and B1 as the emitter.

Testing an IC In-Circuit

This is an experimental testing method and may not be applicable to all ICs. Desolder the terminal with the highest voltage is to be. Set the ohmmeter to the x1 range, place one ohmmeter probe on one terminal and the other on the metal IC casing or the terminal connected to the chassis. If zero resistance was indicated, it implies that the IC has short-circuited. It must be noted that ICs may be damaged in other manners that cannot be identified using an ohmmeter and requires voltage measurement.

27 Frequency Bands

Suppliers may be categorized into the following five groups:

1. The manufacturers of one or more classes of components that have their own sale office. For example:

Onsemi (semiconductor manufacturer)

Saft (battery manufacturer)

AVX (manufacturer of capacitors, crystals, connectors, etc.)

2. Corporate groups that are composed of some manufacturers: from the previous group, selling their products under the same name. For example:

Vishay that incorporates tens of different manufacturers producing components such as capacitors, resistors, diodes, transistors, etc.

Tyco that incorporates tens of different manufacturers producing components such as connectors, relays, diodes, transistors, etc.

3. Dealers with stocks who collect and store all types of components for quick sale. 4. Distributors: These companies are contracted by the

manufacturers and are recognized as the main global distributors. For example:

Avnet, Digikey, Mouser.

5. Commercial component suppliers (or broker) that are scattered throughout the world and supply components directly from the manufacturer based on customer demand.

SMD components are often manufactured in standard dimensions that are indicated by some codes. Some of the best-known codes are as follows:

0402, 0603, 0805, 1008, 1206, 1210, 1410, 1808, 1812, 2417, 2420, 2917

Obtaining (calculating) the SMD size case:

1. The first two digits indicate the length of the component in hundredths of an inch.
2. The second two digits indicate the width of the component in hundredths of an inch.

Example 1:

We have a component that we want to know to which case it belongs. The length and width of the component must be measured. Assuming the component is 3.2 mm long and 1.6 mm wide: $L = 3.2\text{mm} \Rightarrow$

$$3.2\text{mm}/25.4\text{mm} = 0.12" \Rightarrow L = 12$$

$$W = 1.6\text{mm} \Rightarrow 1.6\text{mm}/25.4\text{mm} = 0.06" \Rightarrow W = 06$$

Case = 1206

Example 2:

A component in a catalog is represented by the following size: Case:

$$1812 \quad L = 18 \Rightarrow L = 0.18" = 0.18 \times 25.4 = 4.6\text{mm}$$

$$W = 12 \Rightarrow W = 0.12" = 0.12 \times 25.4 = 3.1\text{mm}$$

$$\text{Case Code: } 1812 \Rightarrow L = 4.6\text{mm}, W = 3.1\text{mm}$$

Codes such as IP 65 are commonly used in catalogs or imprinted on electronic devices. This code shows the level of protection of the device against environmental factors such as water and dust and may be described as follows:

IP 6 7

--- --- --- 1st Digit 2nd digit

The First Digit: Resistance to Solid Particles

The First MeaningDigit

0 Not Protected

1

Resistant to particles as small as 50 mm in diameter

2

Resistant to particles as small as 12.5 mm in diameter

3

Resistant to particles as small as 2.5 mm in diameter

4

Resistant to particles as small as 1 mm in diameter

5 Dust protected

6 Dust-tight

The Second Digit:

Protected against water with harmful impacts

The Second MeaningDigit

0 Not Protected

1 Vertically dripping water

2 Water dripping at an angle of 15°

3 Spraying water

4

Water splashed for a short time period

5 Waterjet

6 Powerful waterjet

7 Temporary immersion

8 Permanent immersion

Electronic components and equipment are often certified by international organizations. This is indicated by the certificate symbols

imprinted on them. Some of these symbols are presented in the following along with the names of their corresponding owners:



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BASEC ==> British Approvals Service for Electric Cables UK

BASEEFA

UK ==> British Approval Service for Electrical Equipment in Flammable Atmosphere

BEAB UK

==> British Electrotechnical Approval Board

BG ==> Berufsgenossenschaft der feinmechanik und Elektrotechnik

BSI UK

==> British Standard Institute

CEBEC ==> Comite Electrotechnique Belge Belgium

CECC ==> CENELEC Electronic Components Committee

CEE ==> Commission L'Equipment Electrique

. ANSI ==> American National Standards Institution USA

ASTA ==> Association of Short Circuit Testing Authorities UK

BABT ==> British Approvals Board of Telecommunications UK

CENELEC ==> European Committee for Electrotechnical Standardization

 **CSA Canada ==> Canadian Standards Association**

DEMKO Denmark ==> Danmarks Elektriske Materielkontrol

 **DIN Germany ==> Deutsche Industrie Norm**

GOST ==> State Committee for Standards USSR

 **IEC ==> International Electromechanical Commission**

IMQ ==> Istituto Italiano del Marchio di Qualita Italy

 **JETL ==> Japanese Electrical Testing Laboratory Japan**

**KEMA-KEUR ==> National Testing Authority for the Netherlands
Holland**

NEMKO Norway ==> Norges Elektriske Materielkontrol

NF-USE France

==> Norme Francaise

OVE Austria ==> Österreeichischer Verband Für Elektrotechnik

SAA Australia ==> Standards Authority of Australia

SABS

South Africa ==> South African Bureau of Standards



RoHS

SECV Australia

==> State Electricity Commission of Victoria

SEMKO Sweden ==> Svenska Elektriske Materielkontrollanstalten

SETI Finland

==> Sähkötarkastuskeskus

SEV Switzerland ==> Schweizerischer Elektrotechnischer Verein

TUV Germany ==> Technischer Überwachungs Verein

UL USA ==> Underwriters Laboratory

UTE France

==> Union Technique L'Electricite

VDE Germany ==> Verband Deutscher Elektrotechniker

==> Restriction of the certain Hazardous Substances (2002)

Row Company

1 1000Bulbs

2 3M

3 Able

4 AEC

5 AIRPAX

6 AKE

7 Alpha

8 Alps

9 AMP

10 Amphenol

11 Analog Device

12 Anaren

13 Anderson Power Products 14 Apem

15 API

16 Arcoelectric

17 Aries

18 Assemtech

19 Assmann

20 Atmel

21 Augat(Alcoswitch)

22 AUK

23 AVA

24 Avago

25 Avnet

26 AVX

27 Batron

28 BC Component

29 Belden

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31 Bourns

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34 Bussmann

35 C&K

36 Cdl

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38 Cherry

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40 Cinch

41 Citizen

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53 Crydom

54 Cypress ind.

55 Datasensor

56 Deltron

57 Digikey

58 EBE

59 Edac

60 ELCO

61 Elite

62 Elna

63 EMP

64 Epcos(siemens components) 65 Erich-jaeger

66 ERNI

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76 Finder

77 Fischer

78 Freescale => NXP

79 Futaba

80 Grayhill

81 Great power

82 Great rubber

83 GTI

84 Hall-fast

85 Hamlin

86 Harbour

87 Harting

88 Harwin

89 Helektra

90 Hella

91 Hengstler

92 Hirschmann

93 Hitachi

94 Hitano

95 Hittite => Analog Device

96 Holmco

97 Honeywell

98 HRS

99 Huber Suhner

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112 JST

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Www.sherlab.com introduces the famous manufacturers of all electronic components. **Www.relayspec.com** is a good place for finding different relays.

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